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ON THE ORIGIN OF SPECIES.*

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WHAT are species? To answer this question is as difficult now as it was in the days of Linnaeus. Formerly it was supposed that a certain number of forms had been created, and that these, obeying natural laws as yet undiscovered, had split up and so given rise to groups, which afterwards were called genera. Such genera were clover, rose and buttercup, plums, apples and pears. Among them, by the addition of a name, certain species were distinguished, such as red clover, white clover, etc.

Linnaeus, in his first publications, adopted the above view. 'Each genus is created as such,' is one of his best known theses. Later he changed this in so far as to declare species created, *i. e.*, those species which he recognized as such, and which he had endowed with binomials. In this manner, the power to split up, to produce new forms, and thus to form groups, was transferred to the species, which offered the great advantage, that, since species greatly surpassed the genera in number, the necessary number of splittings was correspondingly reduced.

Next to the disciples of Linnaeus and a few others who still adhered to the old doctrine, there soon arose a group of botanists and zoologists who went much farther in applying the principle of Linnaeus than was intended by him. The former continued to consider

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genera as created, and species to have originated from them. When the number of known species increased and soon assumed undreamed of proportions, it seemed but natural not to accept for each species a separate creation. But the others denied the possibility of a transition from an old form to a new one by natural means. Each actually existing form, constant from seed, must, according to their idea, have been created as such. They denied the right to collect groups of forms under one specific name, as did Linnaeus and, after him, his disciples, especially when, owing to constant research, an exceedingly large number of forms became known. Instead, they recognized each form as a unity—unities which could be collected under a generic name only.

But Linnaeus, guided more by the talents of a lawyer than by those of an investigator, had once for all connected his conception of a species with the use of the binomials introduced by him. Whatever bears two names is a species. This is the law which all must obey. Genera bear simple names, subdivisions of species tri- or quadrinomials. Whoever wishes to have a form recognized as a species, must give it two names. Unless this be done he will not attain his object. But the number of simple forms, constant from seed, increased year by year and, even for Europe alone, threatened to become ten times greater than it had been.

Since the validity of the theory of descent has been generally recognized, these questions have lost much of their importance.

The work of Darwin embraces two main theses which as a rule are not sufficiently distinguished and which even by him were frequently collated. The one was to ascertain the common descent of plants and animals, the other, to find how one species could have originated from another. These two points are mutually independent, and were especially so at the time of publication of Darwin's 'Origin of Species.'

The doctrine of the common descent of all organisms holds that genera, families and even the larger divisions of the plant- and animal-kingdoms originated in a manner identical with the one which, before the days of Linnæus, was largely accepted for the splitting of genera into species and afterwards for the formation of subspecies from species. The common origin of groups of smaller types was recognized; but how large these groups were no one knew exactly. Darwin extended their limits so as to enclose all li ng organisms, practically collecting them into a single genus.

For this purpose it was not even necessary to know how the simple forms themselves originated. What was conceded for these by every one, had only to be applied to the larger groups. Yet Darwin attached considerable weight to this question and threw much light upon it.

That the smaller species are created as such is the view now held by a comparatively small group of scientists. It is a contention, the truth of which has never been generally recognized, and at the present time has of course lost all right of existence. Before and after Linnaeus, before and after Darwin, the formation of the smaller species, the one from the other, has, except by the few above mentioned, been generally recognized, a recognition based upon experience as well as on tradition.

The smaller species are called subspecies or, as in horticulture, varieties, and are therefore considered as subdivisions of the species of Linnaeus.

Their descent from other species was conceded even before the days of Darwin, but nothing was known regarding the manner of their origin. It was generally deemed sufficient to attribute it to environmental influence. In agriculture and in horticulture it occurred from time to time that new forms originated from older ones; it always happened unexpectedly and without gradual transitions, always by skips and jumps. The new forms were called sports; whether in nature the same thing occurred was unknown.

Both in agriculture and horticulture these sudden changes were very rare and always shrouded in mystery. They occurred without any apparent preparation, the new form appeared unexpectedly, and once its presence had become apparent it was impossible to trace its origin. One could but state the fact, which, for cultivation- and trade-purposes, was deemed quite sufficient; but its nature remained wrapped in darkness. Truly no tempting basis on which to found a grand theory.

It was for this reason that Darwin preferred to turn to more generally known, or, at least, more tangible, facts. He laid much stress on over-production, on the struggle for life which must be the consequence, and on the greater chances of success possessed by the strongest individuals or by those best adapted to their surroundings.

He pointed to the dissimilarity, the so-called variability of individuals, and showed it might be met with everywhere and at all times, in all organs and in all characters. This dissimilarity is decisive in the struggle for life; not in every individual case of course, for here chance plays too prominent a part, but in the majority of cases and in the long run. That which is not fitted for the surroundings must succumb; each species adapts itself more or less to its environment; each species is different in nature from what it would be in the absence of all disturbing influences and were its reproduction unhampered.

How far can variability extend its influence? Has variability its limits? May variability proceed for centuries in the same direction or must it necessarily return to the starting point? Can variability bring about the formation of new characters or new organs or is it

limited to differences in the degree of development of those already extant? Most of these questions were left unanswered at the time and, for the greater part, have remained so. And, as long as no answer was forthcoming, imagination had free play as regards the manner in which one species originated from another.

A stop was put to this when Quetelet discovered his famous law. Variability obeys certain rules; nothing outside the compass of these rules can be attributed to it. Variability is not unlimited and always returns to its starting point. There may be various causes for a prolonged deviation of variability from the mean, of which continued selection of individuals, strongly developed in any particular direction, is the most important; but as soon as these causes cease to exist or this selection ceases to be practiced, it must return to the mean. Variability is nothing but a more or less, a plus-variation or a minus-variation; it does not go in any direction other than the greater or lesser development of a character already present. Variability merely causes a decrease or an increase; it does not create.

It remained for the disciples of Quetelet to draw attention to the consequences of his discovery, which are among the most recent results of scientific research. Darwin and Wallace were not acquainted with these objections to their theory, it was only long after the publication of their works, that science became aware of the existence of these objections and of their importance.

The theory of variability, such as we know it at the present day, does not lead to conclusions favorable to the theory of the gradual origin of species, the theory which assumes that species originated by a gradual increase in the degree of variability. Hence many writers have at various times declared more or less openly against this theory. Others again have tried to reconcile it with the newly discovered facts. But Darwin's explanation is a most plausible one, which, apparently at least, solves all difficulties. And the voice of his antagonists is as yet not so powerful but that the great majority should remain faithful to the old banner.

Besides, Darwin never expressed himself so definitely upon this point as some would have us believe. Openly in one passage, less so in a second one, he acknowledges the possibility of another explanation. It might very well be possible that the changes of the species in nature might occur suddenly, as had been observed to be the case in agriculture and horticulture. This would, as satisfactorily as the theory of gradual change, explain the relationship existing between smaller species in nature and more especially between those agricultural plants which systematic botany unites into a single species. Without a doubt, the formation of the various kinds of beets, of oats or of barley, would have required many centuries, but the results are ac-

counted for as easily by accepting exceedingly slow changes as the causes of the formation of species, as they would be were we to consider them due to shocks occurring but once in a protracted period. Darwin fully realized this and considered the doubt upon this subject as one of the weakest points of his theory.

Darwin, as did many since, compared the origin of species in nature to the methods, ordinarily used in agriculture, to obtain improved races of plants and animals. On this subject much confusion exists. Horses, for instance, are improved principally by crossing with specimens of a superior race, which specimens more or less fully transfer the good qualities of the race to the descendants. But it is certain that in nature the species did not originate in this manner, at least not as a general rule. Improved races are obtained only by careful and constant selection in one direction. This bears a great resemblance to the origin of species, but there is this objection, that such a race would never be independent of selection; as soon as selection ceases, the good qualities disappear. Species and subspecies, even true varieties, on the other hand, are totally independent of the mother species; neither in nature nor in cultivation do they return to the old type, either by a change in environmental conditions or by the cessation of a selection; always provided of course, that accidental crossing is impossible.

The experience yielded by agriculture would lead one to consider a gradual transition from one species into another improbable. They point to a distinct difference between gradually improved races and those suddenly formed, so-called varieties. The former bear no resemblance, the others a resemblance in all respects to wild species.

During the last few decades several writers have expressed themselves more or less strongly against the conception of a gradual origin of species. In America Cope was the one to set the example. Among paleontologists Dollo, among zoologists Bateson, and recently among botanists Korschinsky declared themselves in favor of the doctrine of the discontinuity of the natural ancestral trees. But their opinions have not been sharply defined and formulated and are based upon an acquaintance with facts not much larger than that commanded by Darwin himself. Hence their small influence and the small progress made by their convictions. Hence the American paleontologist Scott, a devoted adherent of Cope's doctrine, deemed it necessary to defend this doctrine against Bateson's book. For his conception of discontinuity is entirely different from that of Bateson. They are both dissatisfied with the reigning views on the origin of species by gradual variability, but in its place each wishes to put an entirely different conception.

It would lead too far were I to enter here upon the various points on which their theories differ; let it be sufficient to note some parts of Scott's treatise, since this gives the sharpest and clearest contrast to the reigning view. In the long ancestral trees which have been brought to light by the study of prehistoric animals, one form leads gradually to another. When the strata are sufficiently known there remain no breaks in the pedigree. Breaks are met with only where the strata are wanting or where it has as yet been impossible to study them thoroughly. Each ancestral tree consists of an uninterrupted series of forms. Between two adjacent ones there exists no greater difference than between the two most closely related species of the present day. And in the successive strata they follow each other up in such a manner as corresponds to the gradual development of the ancestral tree.

But how did each form originate from the one immediately preceding it? Gradually or suddenly? Directly, paleontology can of course not teach us anything upon this subject. Did the species originate suddenly, then there can have been no intermediate forms, but even if they originated gradually the chances that such intermediate forms would have become fossilized, are exceedingly slight. For how small is the proportion of fossilized specimens to those which once must have existed! In any case, no such intermediate forms have been found, and it is for this reason that many paleontologists accept a sudden formation of new forms from the older ones. The transition is slight, as slight for instance as the well-known differences between the local races of slugs; but as these races are constant, so in paleontology are the closest related forms sharply separated from one another.

The contrast between the views of Scott and those of the majority of botanists and zoologists has, I believe, been sufficiently shown here. According to Scott species did not originate gradually, but by small jumps. By each jump a limit was passed, but after that the species remained constant until, perhaps many centuries later, a new shock produced a new form. Each species, each subspecies, or even each variety, is constant in all its characters; they remain the same from the beginning till the end, until, later on, either after having produced other species, or without having done so, they succumb in the struggle for life.

This theory restores the doctrine of the invariability of species to its old place. And this invariability is so general a matter of experience that it has always remained an exceedingly weak point of Darwin's theory of descent. The continual, slow, even inappreciable changes of species, which Darwin, but more especially Wallace and his disciples, accepted, and which are so lineally opposed to every-day expe-

rience, do not exist for Scott. Each species remains unchanged as long as its period of existence lasts. All its characters vary more or less according to the law of Quetelet, but the type, to which all variations return, remains the same through centuries.

A species changes only when it produces others. Or rather, it does not change, but continues to exist next to the species newly formed. It may be compared to a tree, which, though it produces branches, does not cease growing in length. Only when among its descendants there are types better fitted for the battle of life, a species may locally succumb. But it would require a long time before the new species had entirely taken the place of the old.

It is clear that one must distinguish by some simple term variation by jumps from variation obeying the law of Quetelet. It is not practical to use the terms, sport, discontinuous variation or spontaneous variation, since they tend to produce the impression of something incomprehensible. Scott did not use these terms. He speaks of 'mutations.' A mutation occurs when one species is formed from another. As it is, 'mutation' is the expression in general use before the days of Darwin, and at first used by Darwin himself. Since it has apparently fallen into disuse, except in paleontology, where it is met with in various authors, always conveying the same meaning, it seems best to continue to use this term. Hence as long as species produce others they are called mutable, and this part of the doctrine of variability is known as mutability.

Once it has been conceded that species originate from others by mutation, one can go on to investigate what deductions must be made in regard to this process from the facts with which we are acquainted. And as long as an empirical investigation was impossible it was of the utmost importance to be able, even in this manner, to form an opinion about it.

First of all, we can come to the conclusion that mutations must be the smallest changes which can produce a difference between two species or rather between two constant types. Ordinarily the estimation of the differences existing between two related species is too great. Differences as between a horse and a donkey are of course not the result of a single mutation; there must have been a series of transition forms, at present extinct. Nobody will expect to see so great a change occur at once. Even much slighter differences, for instance those existing between our native violets, are still too large; here also there must have existed transition forms. And indeed a comparison with the floras of other countries actually does show a number of forms which bridge over these differences.

Yet differences between species are often so small that only a very careful study can make us acquainted with them. Among our native plants I have but to mention *Cochlearia Anglica* and *C. danica, Lepigonum* [*Spergularia*] *salinum* and *L. medium, Chrysanthemum maritimum* and *C. inodorum, Carex Oederi* and *C. flava.* These are differences which one would rather neglect. Other examples can be met with in the genera *Rosa, Rubus, Salix, Hieracium* and many others; each botanist is acquainted with them, they are the common stumbling-blocks on botanical excursions. Yet in systematic botany they are regularly recognized as *bona fide* species.

It sometimes occurs that two of these species which closely resemble each other grow side by side, as in the instances above-mentioned. In this case one can as a rule compare them when fresh, and in this manner fully realize the differences existing between them. But it happens far more frequently that the two plants, or three or four members of a small group, occur in different countries, often at great distances from one another. Then the differences are far less apparent. To this must be added that by the drying process necessary for herbarium purposes, many characters are lost. In that case the plants are no longer clearly distinguished, and are ordinarily considered as a single species, united under one name. This happens with *Draba verna, Viola tricolor, Helianthemum vulgare* and numerous other plants. It is only when we obtain them from different countries and grow them next to each other in the garden that the differences become apparent, and it is only then that these differences prove to be as great as those existing between the members of the above-mentioned couples of species.

One must therefore consider each mutation a step not greater than the differences between *Chrysanthemum inodorum* and *C. maritimum* for instance. I choose this example because the first species, the double form, with entirely filled, pure white, exceedingly graceful heads, is a well-known component of bridal bouquets. Besides, both are native species and of common occurrence, but generally not distinguished on botanical excursions. Where the differences between related species are greater, the lack of transition forms must be attributed to the fact that these live in other countries, or to their having become extinct.

In the second place, various investigators have come to the conclusion that mutations must occur periodically. For it is only in this manner that we can make the theory of descent agree with the undeniable fact that the species, such as we know them at present, have remained unchanged for centuries. In certain localities, on islands for instance, or places so situated that for centuries no transportation of plants or seeds can have taken place, the individuals of any one

species do not show any or, at least, no constant differences, the above-mentioned couples of species, and compound species excepted. Spruces form a compound species, consisting of numerous types, but the common fir which without doubt is older than our era has remained the same everywhere. It is ever thus; the species do not undergo any gradual change, but each species is constant and remains so until others take its place. It never or but rarely occurs that new species make their appearance in fully investigated countries, unless indeed they happen to have been introduced from elsewhere. Yet it is probable that new species are formed quite frequently, but that, being too weak, they succumb before one becomes aware of their existence.

The numerous small species which are united under the name *Draba verna* are constant to seed, they do not change, besides they are distributed throughout Europe. It is therefore considered probable that there was a time during which they were formed, probably in a comparatively small region in the central part of Europe [at the present day they are most frequent along the Rhine and the Loire], and that in this locality flourished one or more species from which the present forms originated. At the end of this mutation-period the species would again have become constant. In this manner mutable and immutable periods in the development of species would have alternated more or less regularly.

There is a great tendency to consider a rapid increase in number as one of the reasons which cause a species to become temporarily mutable. Many species multiply exceedingly rapidly when they are transported to a new region where the conditions are favorable. Many European plants did this in America, likewise many American plants in Europe, as is only too well known through the waterpest, *Elodea canadensis*. As a matter of fact, we did not see them 'mutate,' but this may have been due to insufficient observation. It would be of great importance to pay close attention to this point when draining lakes, clearing waste lands, after forest fires and in similar cases.

Whether the mutations, during the mutable period, have been one-sided or many-sided, is a most important question and one frequently discussed by the adherents of the mutation theory. The case of *Draba verna*, just mentioned, certainly speaks in favor of many-sided variability; the 200 'subspecies' known, vary in all organs and in all possible ways. Numerous other instances might be quoted. But opposed to them are the results obtained by paleontology. The progress in zoological times, more particularly in the animal kingdom, has always followed definite lines; by a straight line nature tried to reach her goal, not by zigzag lines, feeling her way. The main line has of course numerous small side branches, but branches which do not lead to still living types are rare. Scott and others deduce from this that mutability is one-sided, only progressing in the desired direction. Yet

it might as well be possible that the mutations were many-sided, but that of them only those survived which excelled their ancestors in a particular direction, better fitting them for the existing conditions.

Finally one can come to a very important conclusion in regards the manner in which plants and animals mutate. It is this, that new species did not originate in a single individual, but in a number of individuals, either at the same time or during a number of years. Delboeuf was the first to formulate this idea, and Scott and others agree with him on this point.

This is a quite simple and natural view to take. A single individual would, among all the members of his former species, practically have no chance of life and reproduction, even if it were a hermaphrodite plant and much better adapted to local conditions than the others. For this chance plays too prominent a part in the struggle for life. There are a thousand chances that a seed does not germinate or is killed in its prime, independent of any qualities it may possess. Once the young plant has passed this period, the chances certainly are better, but even then many succumb because they occupy an unfavorable place. But when a plant produces a number of individuals of the new species at the same time, and repeats this for a number of years, then the chances of the new species are sufficient; and this even if it is weaker or in some regards inferior, and certainly if it is as good as the mother species. It is not at all necessary that the new species be stronger, or be at once offered the opportunity to make use of its superior qualities. Delboeuf carefully calculated the chances, but even without these calculations one can see the truth of his remarks. For the larger the number of mutating individuals, and the more generations this mutating lasts, the greater will become the chance of the new species to maintain itself among the old one, always supposing the former is not so weak as to be crowded out each time. To be better equipped than others before entering upon the struggle for life is certainly a great advantage, but not a *sine quâ non* for ultimate success.

Reviewing the above, we find that the mutation theory comprises the following theses. Species originated from others by sudden but small changes, often so small as to be hardly visible to the neophyte. They are constant and true to seed from the first; neither are they connected with the mother species by a series of intermediate forms, nor do they have to pass in their prime, a stage of gradual development. This formation of new forms does not take place continually, but it is only from time to time that a species enters a period of mutability; in this case it produces, during a certain number of years, one or more, perhaps an exceedingly large number of new species. The mother species itself remains unchanged; it may persist after the muta-

ble period is passed, and in that case retains its old characters. The new species make their appearance in several, probably in numerous, individuals, and during each year of the mutation period. If they do not do this, their chances of life are exceedingly small, but in the other case their chances are sufficient, even if the new species are not in any regard superior to the mother species. The weaker ones among the new forms disappear of course very early.

The real struggle for life, in which natural selection must decide whether the young types shall continue to exist or not, only comes later on; it is not a war between species, but against other organisms, and against climate and soil.

In 1886, when I was preparing to write my *Intracellular Pangenesis,* the above mentioned considerations were only partly known to me. De Bary's studies on *Draba verna* only appeared in 1889, Bateson's book in 1894, Scott's article a little later, etc. But what was known at this time was sufficient to convince me that the formation of species should lend itself to experimental investigation. This was certainly directly opposed to the *reigning* opinion and especially the conception of a slow and gradual origin was not in favor of my view. It was thought that sudden transitions were limited to the so-called varieties, that they occurred in agriculture and horticulture only, and besides so rarely that an actual study of the problem was not to be thought of.

I then began a more systematic study of the variability of plants, a subject which always had possessed a great attraction for me. It very soon became apparent that observations in nature and in the garden could not lead to the desired goal. Even if one pays constant attention to the same individuals and the same localities, visiting them in various seasons and in different years, the observations remain too incomplete. This is but natural, since mutability commences with the seed and in nature but comparatively little seed, after germinating, attains its full development. I therefore decided to have recourse to sowing-experiments and for this purpose collected as much seed as possible from wild growing plants.

This seed was sown in my experimental garden, in some cases on quite a large scale. Besides I sowed seed gathered from some specimens of wild plants growing isolated in the garden. It was of course my aim to try to find among them one or more species which were passing through a mutation period. Among the seed sown was for instance that of *Verbascum thapsiforme, Thrincia hirta, Crepis biennis, Centaurea nigra, Capsella Bursa pastoris, Bidens cernua, Aster Tripolium, Cynoglossum officinale, Sisymbrium Alliaria, Daucus Carota,* and a number of other wild plants. As far as possible I allowed myself

to be guided by symptoms of a particular tendency to variability, and hence chose by preference seed from plants with fasciated stems, split leaves or other variations. I also sowed, as far as room permitted, seed of annual garden plants, bought in shops.

It is clear that, notwithstanding the immense amount of work involved, the chances of success were exceedingly small. Yet I was lucky enough to find the very thing wanted. Among a hundred species there was a single one which proved to be mutable, at first but in a small degree, but sufficiently to decide me to abandon nearly all other experiments and to study this one plant as thoroughly as possible. Of the other species I had in the meantime obtained a number of monstrous races; these I continued to cultivate, but not the others.

The plant referred to was *Oenothera Lamarckiana,* a species of American origin, which has here escaped from cultivation, as did formerly both the evening primroses, *Oenothera biennis* and *Oenothera muricata,* which at the present time are quite common on our sand dunes. *Oenothera Lamarckiana,* the large evening primrose, surpasses both other species in size of flowers, but for the rest is very much like them. This plant was first described by Lamarck as *Oenothera grandiflora,* but by this name a number of other species of *Oenothera* are known. Seringe changed the name to *Oenothera Lamarckiana,* which name has been retained.

In 1886 I collected a quantity of seed from wild plants of *Oenothera Lamarckiana* and also transported a number of rosettes of biennial specimens to the botanical garden at Amsterdam. The next year they flowered profusely and produced a large quantity of seed.

The seed obtained from wild plants was sown in 1887 and yielded at once what we desired. For among the plants obtained from it, there were three which, though agreeing among each other, possessed characters entirely deviating from those of the rest. This species was, therefore, able to produce at least one new form. The new form differed more from the mother species than the three species above mentioned did among each other. The leaves were broader, rounder and more obtuse, the buds swollen and the fruits small. The stems were small, weak and remained brittle even in autumn. At the tips of the branches the young leaves and buds were collected in crowded rosettes, so that at first the plants were denoted 'roundheads.' In a number of other particulars they differed more or less from the ordinary form, in fact they did not entirely agree with it in a single point. The most important difference, however, was the inability to produce good pollen. The anthers of the mother species are, when open, thickly covered with a sticky powder, which is entirely lacking in the case of the roundheads. The anthers of the new form are dry, what little pollen there is is shriveled, for the greater part unfertile and entirely unfit for

fertilization. The plant is purely feminine. Male or hermaphrodite specimens I never saw, though I have often cultivated hundreds of roundheads. On account of the broad leaves, and thick buds, *Oenothera lata* was chosen as the systematic name.

Encouraged by these results, I continued my investigation, partly, during the same year, by a closer study of the locality where the seed was collected, partly by sowing experiments on a large scale in the spring of the year following. The former made me acquainted with two new types, which had remained unobserved in 1886, but which, as rosettes of root-leaves, must have been present at the time, since *Oenothera Lamarckiana* is, in that locality, biennial, with hardly any exception. The one was glabrous, more delicate and more graceful, but as robust as the common form, the other had so short a style that the stigma, instead of protruding far above the stamens, was situated at the base of the flower. Both forms were formerly absolutely unknown, and, later on, in the sowing-experiments, proved to be as constant and true to seed as the mother species. That they originated in the locality where they were found may be considered as certain, but how this happened could not be investigated.

The seed, sown in the spring of the following year, again yielded two new forms. The one was a dwarf form, such a one as occurs from time to time among all kinds of culture plants—but a few decimeters high, whereas the mother species attains a height of 1½ to 2 meters and more. The other was a form with shiny leaves, about half the size of *Oenothera Lamarckiana,* narrow, dark green, and very graceful. Both were quite fertile and produced a large quantity of seed.

Dwarf forms are ordinarily described along with the species to which they belong, as *varietas nana* or *nanella,* and my dwarf forms agree with them in every respect. They offer a good contrast with the other types, which cannot be termed varieties in the ordinary sense. For, in the first place, they deviate from the parent species not in a single character, but in all, and, in the second, they do not have their parallel in other genera. For repetition, such as appearance of white flowers, glabrous leaves, thornless stems and fruits, unbranched stems, variegated leaves, double flowers, etc., is one of the most common characteristics of true varieties.

Later the dwarfs proved to be constant to seed. Not so the shiny variety. Though I did not sow the latter each year, I did it frequently; its characters reappeared as a rule in but about one third of the individuals.

By sowing I obtained in 1888 nearly 15,000 plants, among which there were five dwarfs and five *latas,* that is to say, of each about 1 on every 3,000. In later years, when I became familiar with the most favorable methods of treatment, the percentage increased considerably,

until at last there appeared approximately one new form on every 100 individuals.

The *latas* were, as we have seen, obtained partly from seed collected from wild plants and partly from seed yielded by wild plants transported to and cultivated in the botanic garden. Yet they agreed entirely in all respects, forming but a single well-defined type. Later in 1889 and in 1894, I also found them in the original locality.* In my garden they made their appearance nearly every year. Each *lata*-plant which, without similar ancestors, originated from the *Oenothera Lamarckiana,* bears always exactly the same characters; one can always recognize it shortly after germination, and predict at the time all characters which it will exhibit later on. The same is true for the dwarfs, for the shiny forms, etc.

Once the certainty obtained of having found a mutating plant, I of course applied myself as closely as possible to a study of this phenomenon. Naturally this was at first connected with great difficulties, especially because I did not have an exact idea of what I was to look for. It was only in 1895 that I succeeded in surmounting these difficulties. I had by that time realized how small were the differences to which I had to pay attention, and that these differences, at least for the greater part, are apparent in the earliest stages of development. I therefore sowed on a large scale, reviewed my plants nearly daily, and changed each clearly deviating form to another bed, where it was given plenty of room and tended with great care.

That year I obtained about 14,000 plants from seed. Dwarfs and roundheads made their appearance in large numbers, 60 of the former and 73 of the latter. Their parents had been ordinary *Lamarckianas,* carefully pollinated with each other's pollen, as had been their ancestors of the last two generations and therefore of pure descent, as were probably all their ancestors of the original locality. The shiny form also made its appearance, again in but a single specimen. Besides there appeared five entirely new forms; three of these were separated as rosettes, one only showed itself to be a new form, when flowering, and the other only during the next year after hibernating.

The last two were rare, the one, *O. leptocarpa,* appeared in two specimens, the other, *O. gigas,* in a single individual. Both are at present constant to seed, absolutely unchangeable. The former is not beautiful, but ranker and taller than *O. Lamarckiana,* and flowers later in the season. *Oenothera gigas,* on the other hand, is a splendid, exceedingly robust plant, which, with a rich crown of very large flowers, easily excels the mother species.

The three others I denoted as 'red-nerved,' *O. rubrinervis,* 'white,' *O. albida,* and *O. oblonga.* They appeared respectively in 8, 15 and

* Likewise this year [1902].

176 specimens. The whites were very weak, and all of them died without flowering. But they reappeared each year, and in 1897 I succeeded in getting them to blossom. After that they proved to be constant and true to seed. The same is true for the red-nerved ones and for the *oblongas,* which are very typical and easily cultivated species.

Since 1895 I have each year sown *Oenothera Lamarckiana,* always taking care that the seed was pure. Fertilization was always artificial, with their own pollen, and with the exclusion of all insects. Yearly I had a thousand or more seedlings and regularly found among them a number of mutations. The new forms with which I already was acquainted reappeared each time; with a single exception no others have been added. The percentage of mutants remained the same each year, of course with slight variations.

Repeatedly I saw new species originate which either did not flower or were sterile or which on account of general weakness succumbed early in life. Some of these clearly originated several times, others so rarely that it was practically impossible to make a diagnosis. A few of these I also found in the original locality. Hence nature evidently makes besides species capable of existence also those which are not so. The latter disappear very soon and hence are hardly ever seen; the former persist for a greater or smaller number of years.

The above may be considered sufficient to prove that the origin of species is a phenomenon falling entirely within the limits of ordinary observation. One has but to search his surroundings for a plant which happens to be passing through a mutation period to be able to study the entire process. Transportation to the garden only serves to make isolation of the plant possible; it but shows what happens in nature, but which there, on account of unfavorable conditions, is but seldom or imperfectly observed.

At the same time one sees that experiment, in this first example, confirms the deductions made a long time since from paleontological and biological data.

Delboeuf, as well as Scott, requires that each new species does not appear in a single specimen, but in a number of specimens, and not once but during a number of years. For only under these conditions are their chances sufficient. It is exactly this which happens with the *Oenotheras.* They are formed each year, 1 per 1,000 or 1 per 100, in any case in a sufficiently large number to fall within the requirements formulated by the savants just mentioned. They are with a single exception at once constant from seed, without ever returning to the type of the mother species; they would, by sufficient isolation, at once form groups of uniform individuals. Nothing indicates their appearance in advance, there is not even a hint of transition; once formed

they are perfect, and retain, even after several generations, their original characters. They originate with a shock or jump and then are constant.

They are formed from the mother species as side issues, and not because the mother species undergoes a gradual change. On the contrary in nearly all mutations, the species continues unchanged, and to it belongs the great mass of individuals, until one day the struggle for life shall turn the scales.

Mutability is not one-sided, as many paleontological series would lead one to expect, but many-sided as must be deduced from the principles laid down by Darwin. And the new *Oenotheras* vary in different organs and in various directions; most frequently the new characters are injurious, sometimes indifferent, occasionally beneficial, probably at least. Next to strong new species there occur weak ones, next to these, those so weak as never to reach the flowering period; and finally sterile forms. From this array of forms nature, in the struggle for life, later on makes its choice; only those most fit continue to exist. Even here experiment confirms theory.

What is the duration of a mutation period? Geology answers: probably very long, for otherwise the chances of life of the new species would be too small. And it seems to me that in the case of *Oenothera Lamarckiana* I have seen neither the beginning nor the end. The fifteen years during which I studied the species comprises probably but a very small part of that period.

MENTAL AND MORAL HEREDITY IN ROYALTY. IX.

By Dr. FREDERICK ADAMS WOODS,
HARVARD UNIVERSITY.

Regression to the Mean.

BY taking each country separately and analyzing it minutely, we have seen how almost perfect heredity appears to be as a cause of the mental and moral peculiarities wherever found. In order to ascertain if talent is properly related to genius in point of consanguinity, so that we have a progressive falling off in relationship to 9,10 grades as we descend from the high ranks to the mediocrities, a count has been made of the number of geniuses (9, 10 grades) which each person possesses as a blood relation both in the first degree of consanguinity and in the second. By the first degree is meant the number of geniuses who are as closely related as father, mother, brother, sister, son or daughter. The second degree includes also grandparents, uncles, aunts, grandchildren, nephews and nieces. If the proportionate relationship of geniuses to men and women of their own type is greater for the first degree of relationship than for the second, we shall see the principle of heredity satisfied, especially if the ratio is the same as found by other observers for physical traits.

The curves show that such is the case, and we have an almost perfect rise in eminent relationship as we ascend from mediocrity to the highest scale. This is true for both the males and females. The average of both sexes smoothes out the curve and gives an even more regular rise than is given by each sex separately. It is to be remembered that such facts mean a great deal since were the geniuses scattered over the entire number, without any law of distribution in regard to blood—as I claim they should be from the effect of environment on the intellectual side at least—there would be instead a reverse of the facts, or an actual falling off in percentage of eminent relations among the higher grades.

This can be made clear by considering any one instance. Take the case of Catherine II. of Russia. All her near relations receive one count for being related to her, yet she herself receives no count, since none of her near relations stand in a 9 or 10 grade. The same would be true of Frederick the Great were he the only one in his immediate family who belonged to 9 or 10 grade. As a matter of fact he counts 6 such relations.

The accompanying curves (Plate I.) show the percentage of eminent (or 9, 10) relations which each grade possesses. The lower lines show

the considerable falling off for mediocrity when only the first degree of relationship is considered, but it will be seen that the falling off is relatively greater when we consider the eminent relations of mediocrities than when we regard the eminent relations of geniuses.

In the second degree of relationship the average of the 9, 10 have about 1.7 eminent relations while the mediocrities have about .6. In the first degree the average of the 9, 10 have about .85 eminent relations while the mediocrities have but about .2. In other words, in

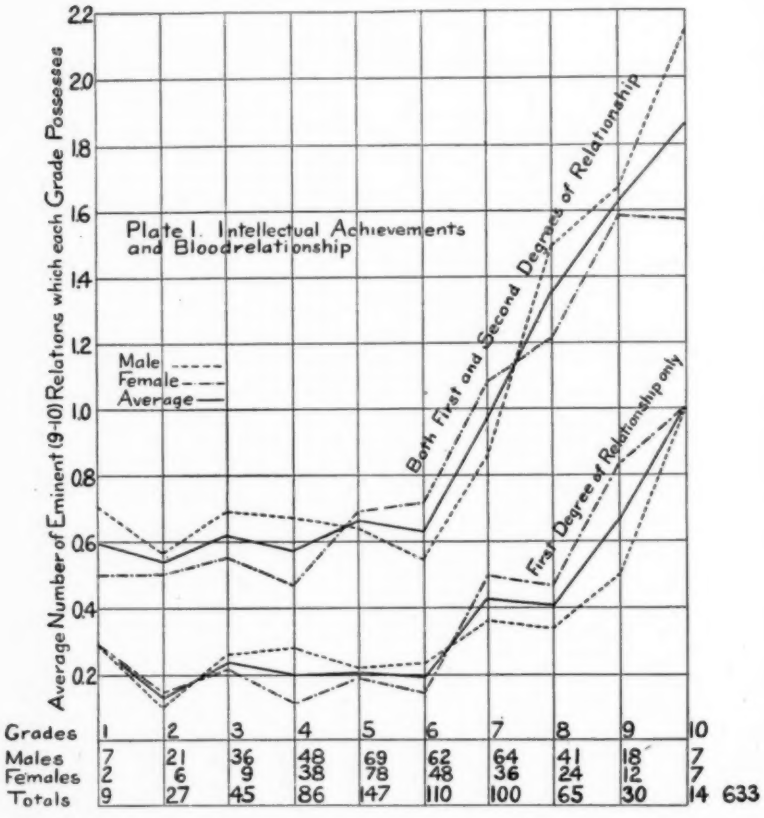


Plate I. Intellectual Achievements and Bloodrelationship
Average Number of Eminent (9-10) Relations which each Grade Possesses
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Male
Female
Average
Both First and Second Degrees of Relationship
First Degree of Relationship only
Grades 1 2 3 4 5 6 7 8 9 10
Males 7 21 36 48 69 62 64 41 18 7
Females 2 6 9 38 78 48 36 24 12 7
Totals 9 27 45 86 147 110 100 65 30 14 633

the second degree the geniuses have about 2.83 times as many relations in the genius grades as the mediocrities have, while in the first degree they have about 4.25 or the regression from the first to the second degree is .6659. This is strikingly close to Galton's first estimate for filial and fraternal regression given in 'Natural Inheritance,' p. 133, as $\frac{2}{3}$.

With regard to the relationship between genius and insanity, it is to be observed that the line does not fall off as we go from the mediocre

to the lowest grades. This would confirm the results obtained by Havelock Ellis in his study of British genius that there is a slight relationship between genius and insanity, though nothing like as much as is claimed by Lombroso.

Grade 10 for intellect contains, as Plate I. shows, only fourteen persons. The names of the men are here given as a sample: also the eighteen who belong to grade 9. Probably few will question the right of the following to enter these elect grades, though some might place one or two a grade higher or lower. The number of relations in the 9 or 10 grades which each person possesses is placed on the left, the first figure being for the first and second degree, the second figure being the number in the first degree alone or the number of (9, 10) relations as close as father or son.

GRADE 10 (NAMES ALPHABETICALLY).

1,1, Bourbon, Condé, Louis II., 'The Great Condé.'
4,1, Orange, William the Silent.
1,1, Portugal, John I., 'The Great.'
0,0, Prussia, Hohenzollern, Frederick William the 'Great Elector.'
6,3, Prussia, Frederick the Great.
1,0, Sweden, Gustavus Vasa, Founder of the Dynasty.
2,1, Sweden, Gustavus Adolphus, 'The Great.'

15,7

The fractions 15/7 and 7/7 give us the averages 2.14 and 1.00 found on Plate I. (See dotted line for males.)

GRADE 9.

1,0, Austria, The Archduke Charles, who commanded against Napoleon, b. 1771.
1,0, Don John of Austria. Celebrated naval commander.
1,1, Austria, Maximilian I., Emperor, b. 1459.
3,1, Bourbon, Henry IV., King of France.
0,0, Caspard de Coligny. The great admiral of France.
1,0, Alexander Farnese.
6,3, Hohenzollern. Henry, brother of Frederick the Great. Considered by many to be the equal of Frederick.
4,1, Orange, Maurice of Nassau. One of the greatest captains of modern times.
1,0, Orange, William III., King of England.
0,0, Portugal, Alfonso I., Founder of the Kingdom.
1,0, " Diniz, 'Father of his Country.'
1,1, " Henry 'the Navigator' celebrated as a mathematician. Son of John 'The Great.'
1,1, Romanhof, Peter the Great of Russia.
0,0, Savoy, Prince Eugene, celebrated general.
1,0, Saxony, Maurice Elector of, celebrated general.
0,0, Sweden, Charles XII., military genius.

5,1, Sweden, Gustavus III., extraordinary mind. His large eminent relationship is Hohenzollern due to his being a nephew of Frederick the Great.

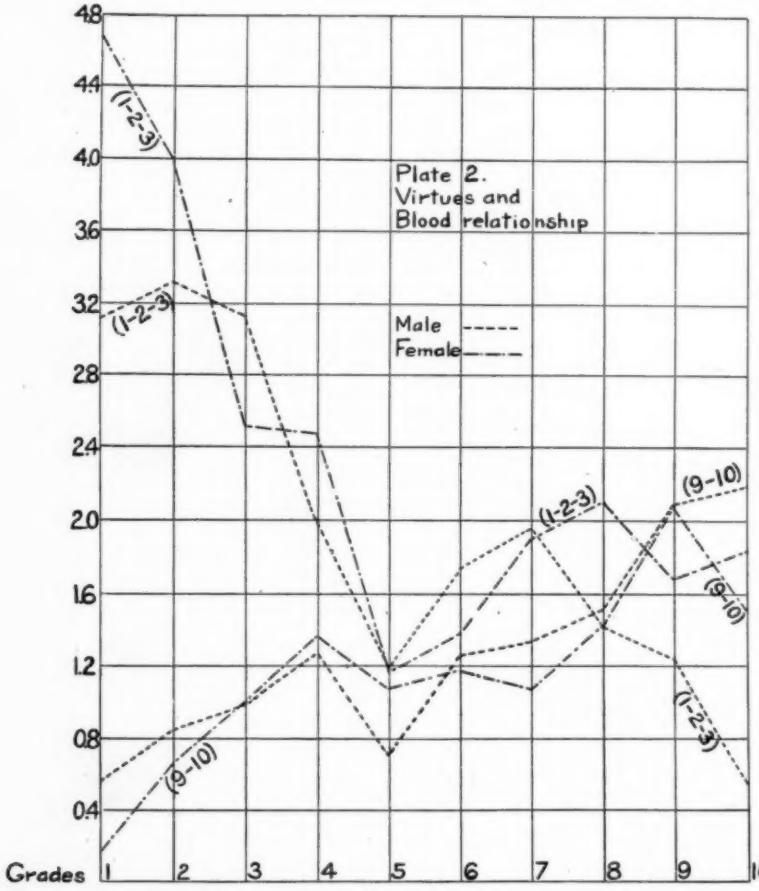
3,0, Tour. Great Turenne, celebrated commander.

30,9

Since there are eighteen persons in this group, the fractions 30/18 and 9/18 give us the averages 1.67 and .50 seen in Plate I. to be the figures for grade 9.

The Inheritance of Moral Qualities.

The reasons for the belief that heredity is almost the entire cause for the mental achievements of these men and women and that environ-



ment must consequently play a very minor rôle, have already been given. The reasons are of a twofold nature. First, the practically perfect results derived from what might be expected of heredity, both

from the internal study of the families separately and from the curves of correlated relationships in the first and second degree. Second, the belief of the author that environment would not cause the great names to be associated in blood.

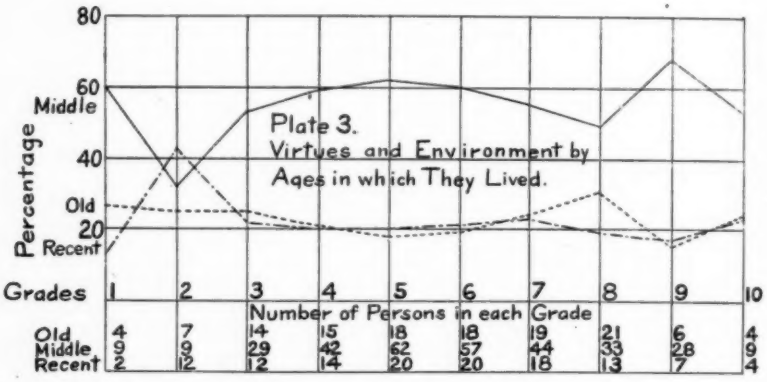
If a great king succeeds in building up an extended empire, it does not appear to the writer that his son would have an easier task in becoming famous as a great governor. The importance which Prussia assumed under the Great Elector did not make his son, Frederick I., rank any higher than 3 in our scale. Still the genius has always been properly perpetuated somewhere, in some of the descendants. Also the times have continually 'called for great men.' Never did a dying country call more urgently than Spain in her last three centuries; yet none appeared. Italy had to wait fifty years for Cavour, Garibaldi and Victor Emanuel. England could not get a good Stuart, but in a descendant of William the Silent she found a hero in William III.

When we come to analyzing the moral qualities we find more difficulty than in the mental. First, because good parentage would tend to bring a better environment; and, second, because the curves of distribution, though in general entirely compatible with hereditary influence, are less perfect. Still it has come to be the belief of the author that even on the moral side heredity is more important than surroundings for the following reasons: First let us consider the curves of relationship. It will be seen (Plate II.) that the men and women in the high grades have some three times as many relations of their own kind as the bad characters have in the way of relationship to these best ranks. The degenerates (grades 1, 2, 3,) have between two or three times as many relations of their own ilk as the best have in these lower grades, while the best have actually more in their own 9, 10 grades than they have in the three lower grades put together. A second reason is drawn from a count of the different grades relative to the period in which they lived. We might expect that in the old days, when the standard of morality was rough, lawlessness and licentiousness would be found in a greater percentage than during more recent times. Three divisions have been made.

The period prior to the year 1600 is here called 'old'; from 1600 to 1800, 'middle'; from 1800 onward, 'recent.' It will be seen in the chart (Plate III.) that the proportionate distinction of characters according to this method arranges them in each rank, almost perfectly according to the law of 'deviation from an average,' each group old, middle and recent, falling off equally from the mediocrities, so that when we attempt to make curves for old, middle and recent, according to the percentage in each rank, we get no curves at all, but lines almost flat. The only irregularities are at the edges 1, 2 and 9, 10 grades,

and mean only that here the instances are too few to make them group themselves in perfect harmony.

I was somewhat surprised that the recent royalty should not give a better showing than the more ancient members, but this is because modern royalty, that is, from 1600 up to 1850, has such a large percentage of badly selected Bourbon blood in it. If we took royalty as it exists to-day we should undoubtedly find a much higher tone, but this is to be ascribed to the fact that most of the existing members are derived from Saxe-Coburg and other excellent German families. Up to 1850 France, Spain, Portugal and Italy were full of Bourbon blood, and we have seen that nineteenth century demands or the awful example of predecessors had no effect on it.


80
60
Middle
40
Old
20
Recent
Percentage
Plate 3.
Virtues and Environment by
Ages in which They Lived.
Grades 1 2 3 4 5 6 7 8 9 10
Number of Persons in each Grade
Old 4 7 14 15 18 18 19 21 6 4
Middle 9 9 29 42 62 57 44 33 28 9
Recent 2 12 12 14 20 20 18 13 7 4

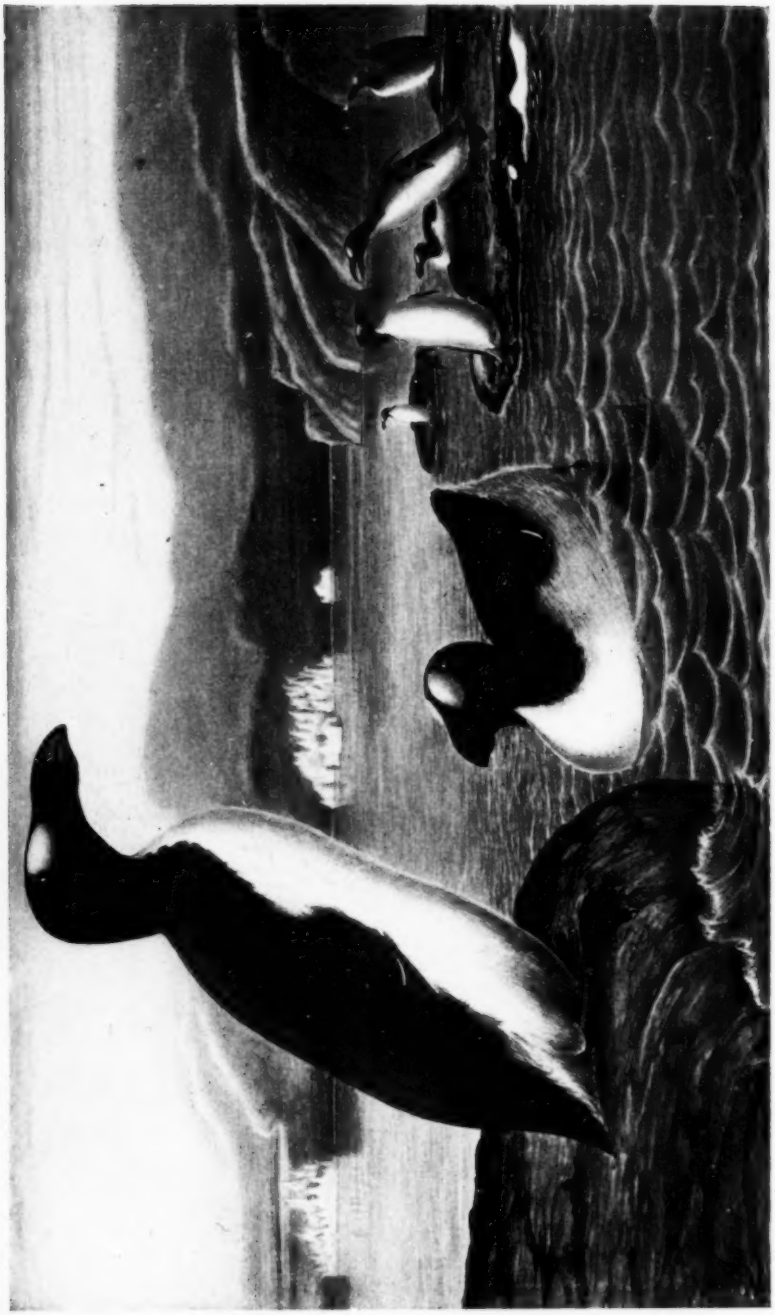
Another way of attacking the problem is the study of each country separately. Spain, France and Russia give us most of the moral degenerates. In all these the individuals are closely associated in blood with a marked mental neurosis. This is of itself a coincidence to be explained by those who doubt the inherited nature of morality, and besides this we have to consider the fact that prior to the appearance of the moral depravity and mental unbalance as well, there was a period when these countries were relatively free from such degenerate types.

Why did the three rulers of the Romanhof dynasty who lived before Peter the Great, in whose generation the neurosis first appeared, exhibit such mild and amiable characteristics, although arbitrary rulers of an ignorant people, and living in the rudest epochs? Then suddenly, with the appearance of the epilepsy and imbecility, we find such examples of moral depravity as the Empress Elizabeth. Strangely among the degenerates we find her sister Anne 'serious, cultivated and virtuous.' Some might contend that rude conditions brought out both good and bad, but then they would have to explain why in Germany

(Saxe-Coburg, etc.) even in the earliest times here traced, we find practically no such variation in characters. They also would have to explain why in Spain and Italy in the nineteenth century, we also find a variation in moral characters exactly like that found in Russia in the early eighteenth or in Spain in the sixteenth centuries.

Another aspect of the question, that is more in line with heredity than environment, is the fact that variations among the children are always duplicated by corresponding variations in the ancestry. This is equally true of both mental and moral and indeed facial characteristics. Children born of the same parents and reared in the same court must usually have pretty nearly the same surroundings, yet instead of their being molded to any standard type, we find that when the blood is diverse in character, just about the proper proportion of children show these same peculiarities both for good and bad. It is only when the blood is uniformly good as in the families of Brunswick, Saxe-Coburg and Sallefeld that we find unanimity in the morality of the descendants.

So that heredity appears to the writer to have exercised in mental life a factor not far from nine tenths, while from the moral side it is something over one half. As to anything in the nature of 'soul' or 'free-will' in the sense of a motive power lying outside of natural laws, such evidence can not, of course, exclude its existence. It does, however, show that such a power, if it exists at all, has only a very minor influence, and even the arch argument of theology, the heroic soul who tries and tries again, is found to be but the reduplication of another. So it appears that the three possible factors in mental and moral life are to be expressed in the following order: Heredity, Environment, and finally, printed with the same old question mark. Free-will.



THE GREAT AUK.

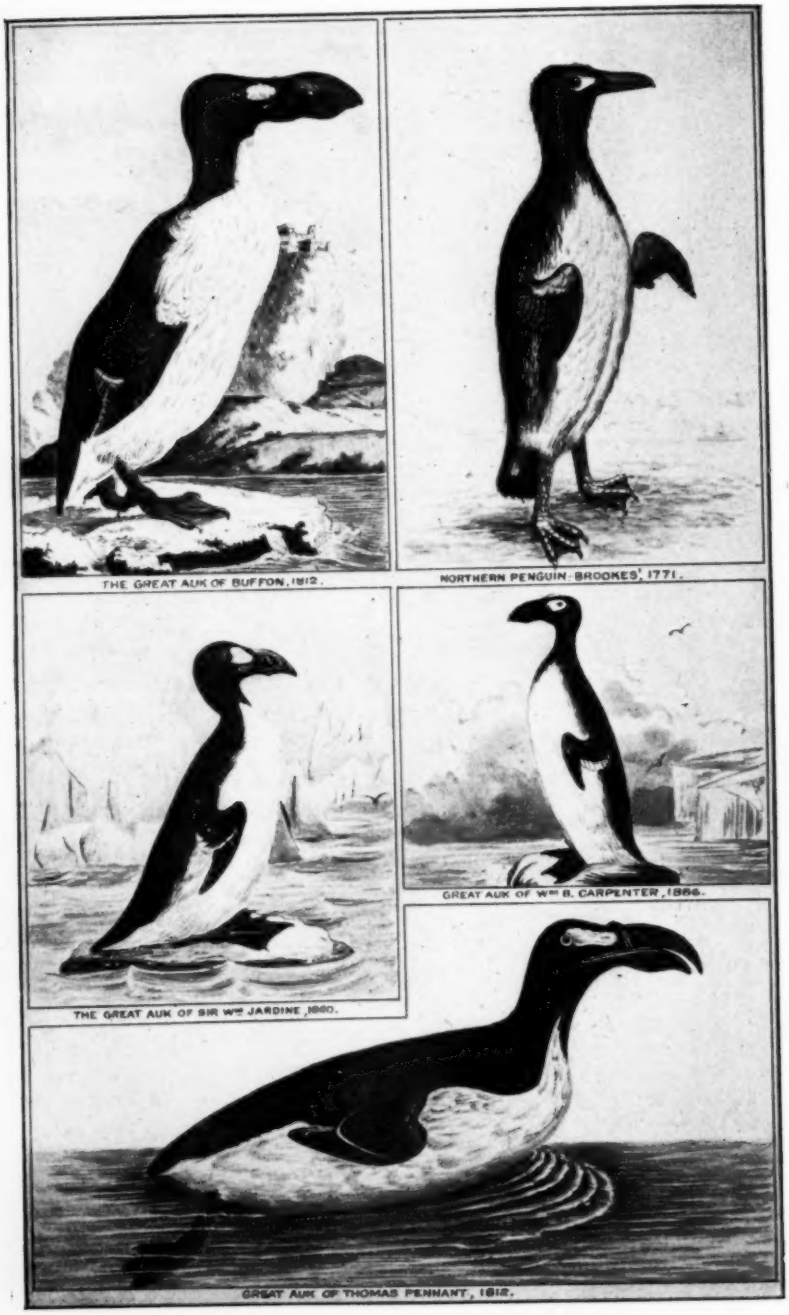
THE GREAT AUK IN ART.

By FRANK BOND,
U. S. DEPARTMENT OF AGRICULTURE.

A CAREFUL examination and comparison of the available illustrations of the great auk leaves the mind in some doubt as to the appearance of this extinct, flightless bird. Some of these illustrations are found in recent publications, while others illuminate descriptive articles written over a century ago. A few voyagers, notably Richard Hakluyt, sometime preacher, and M. Martin, Gent., undoubtedly saw the bird in great abundance on certain islands of the north Atlantic which were notorious as the home of the auk—Hakluyt on the American side and Martin off the coast of Scotland. But neither of these travelers left even a rough sketch of what his eyes saw. Zoologists, naturalists, taxidermists and ornithologists have, however, given us their conception of the bird in black and white, and a number of their illustrations are reproduced and accompany this article.

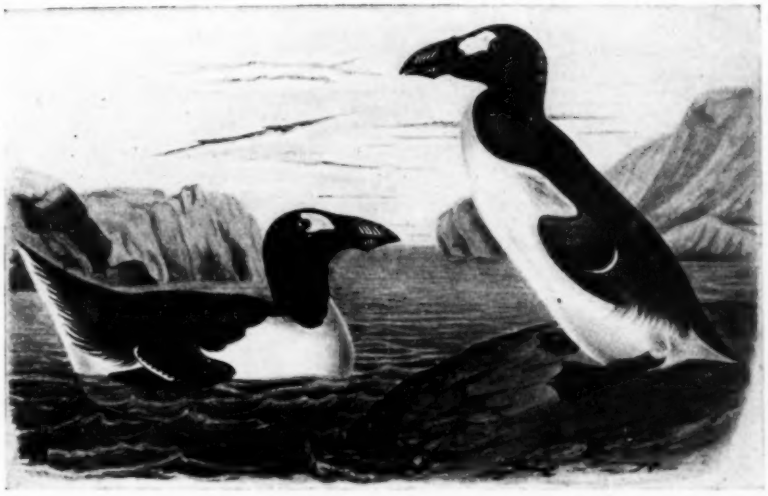
Undoubtedly the only sources of inspiration for the earlier drawings are the written descriptions of the bird, or the attempts to reconcile several divergent descriptions by a plate which would strike a happy mean, the dried skin coming in later as a desirable artists' accessory. The mounted skin also has had a baneful influence upon the pencil of the artist, for in no other way can the differences in form and outline be understood or the reckless indifference to details be satisfactorily explained. Turning to the sources of inspiration which are chiefly responsible for the erroneous, visual evidence of extinction of as many species of great auk as there are drawings of the bird extant, we find that descriptions in detail force a most charitable view of the shortcomings of the pencil and brush. One would not be justified in charging superlative imaginative powers upon the artists, until the apparent mendacities of the writers had been explained. However, to careless observation and lack of familiarity with birds may be charged the majority of the mistakes of both pen and brush. A careful sifting of the available evidence seems to warrant the conclusion that the pictures of the great auk, heretofore published, are defective in many important particulars. These will be considered later in detail.

In the following paragraphs descriptions of similar parts of the great auk, furnished by writers of the past 320 years, are grouped together making comparison easy and the fact that the quotations from some of these authors cover but a point or two does not render the information given by them any the less interesting. That but three


THE GREAT AUK OF BUFFON, 1812.
NORTHERN PENGUIN BROOKES' 1771.
THE GREAT AUK OF SIR Wm JARDINE, 1860.
GREAT AUK OF Wm B. CARPENTER, 1866.
GREAT AUK OF THOMAS PENNANT, 1812.

of the authors quoted below, Hakluyt 1583, Wormius 1655, and Martin 1697, ever saw the great auk alive or in the flesh is an item of more than passing interest.

Size of the Great Auk.—Very large, not much less than a goose—Hakluyt, 1583. Did not much exceed the bigness of a goose—Wormius, 1655. Above the size of a Solan goose—Martin, 1697. Size of a goose—Brookes, 1771. Three feet to the end of the toes—Pennant, 1812. Three feet long, size of a goose but slender—Buffon, 1812. Approaches that of a goose—Cuvier, 1817. Approaches a goose—Willoughby. Length to end of tail, 29 ins., 31½ ins. to end of feet—Audubon, 1840. Thirty inches to three feet—Jardine, 1860. About 3 feet long—Dallas, 1867. Size of a goose—Seebohm, 1886. Twenty-seven and a half inches to tail—Duchaussoy, 1897.



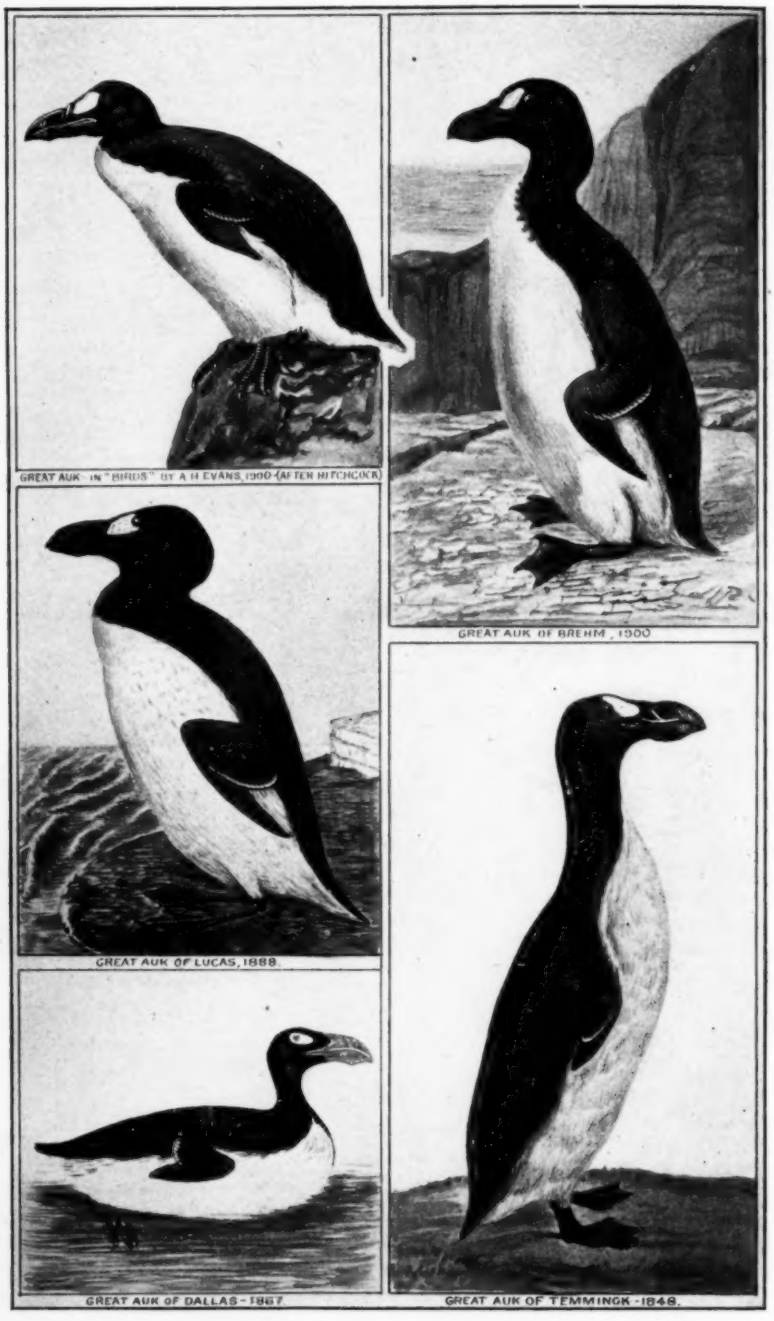
THE GREAT AUK OF AUDUBON.

Bill of the Auk.—A long broad bill—Martin, 1697. Like a broad cutlass, sides flat and hollowed with notches—Buffon, 1812. Marked with several furrows—Pennant, 1812. Black, with 8 or 10 grooves, long and broad—Cuvier, 1817. Black with grooves between transverse ridges white—Audubon, 1840. Black with transverse furrows, the grooves white—Jardine, 1860. White grooves less conspicuous than in Razorbills—Seebohm, 1886. Bill black with 7 or 8 whitish grooves on upper, 10 or 11 on lower—Duchaussoy, 1897.

White Marks on Head.—Large white spot *under* each eye, red about the eyes—Martin, 1697. White oval spot before the eye—Linnaeus, 1761. Large white spot between eye and bill—Pennant, 1812. Great oval white spot between bill and eye, margin rising like a rim on each side of the head, which is very flat—Buffon, 1812. Oval white patch between the eye and bill—Cuvier, 1817. Large oblong white patch before each eye—Audubon, 1840. In front and *around the eyes* is a large oval patch of white—Jardine, 1860. White oval patch from eye to bill—Seebohm, 1886. In front of eyes oval white spot on side of head from base of bill—Duchaussoy, 1897.

Description of Neck.—Short and thick—Audubon, 1840.

Character of Wing.—Cannot flie, their wings not able to carry them—Hakluyt, 1583. Its wings short, it flies not at all—Martin, 1697. So small as to


GREAT AUK - IN "BIRDS" BY A H EVANS, 1900 (AFTER HITCHCOCK)
GREAT AUK OF BREHM, 1900
GREAT AUK OF LUCAS, 1888
GREAT AUK OF DALLAS - 1867
GREAT AUK OF TEMMINCK - 1848.

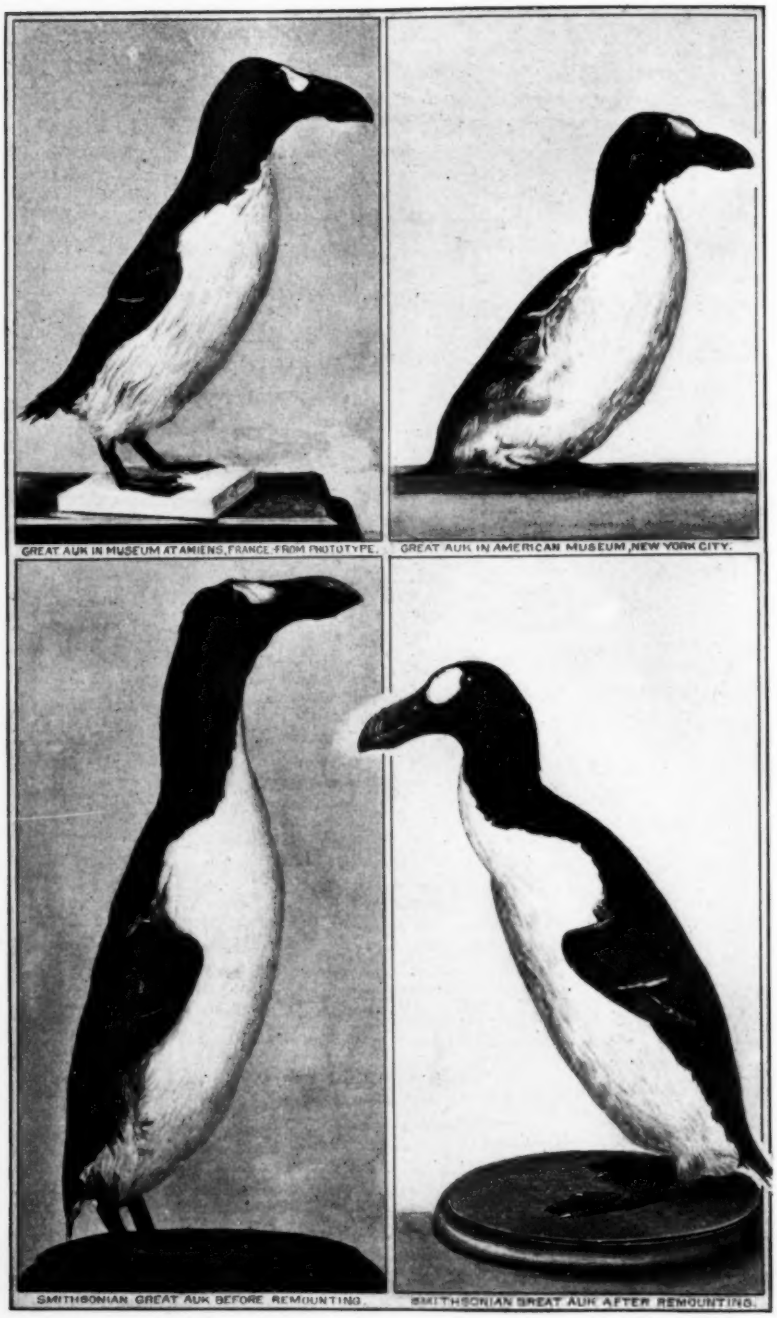
be useless in flight, four inches from tip to first joint—Pennant, 1812. Great feathers exceed not 3 inches in length, cannot raise into the air—Buffon, 1812. Very small in proportion to other birds, for subaquatic progression—Cuvier, 1817. Extremely small but perfectly formed—Audubon, 1840. Very small although formed of regular feathers, serve as fins when diving—Dallas, 1867. Like small duck—Seebohm, 1886. Rudimentary, useless for flight; used in swimming and diving—Duchaussoy, 1897.

Feet.—She is whole-footed—Martin, 1697. Placed far behind, but very strong—Audubon, 1840.

SMITHSONIAN GREAT AUK SKELETON.

Attitude and Mode of Progression.—Stands stately, its whole body erected—Martin, 1697. Can scarcely even walk; pace heavy and sluggish; lies stretched out on rocks and ice; erect attitude is painful—Buffon, 1812. Stood very erect, never flapped along water surface—Wooley, 1858. Only shuffled along—Seebohm, 1886.

After having compared the above descriptions, one is not inclined to criticize harshly the illustrations based upon them, except in cases where the author, after having carefully noted an important specific marking, entirely omits it in his drawing. The white spots on either side of the head of the great auk seem to have been a most serious stumbling-block to writers and artists alike. Martin, in 1697, states that the white spot is *under* the eye. No other description agrees with this, and the photographs of mounted skins show no such phenomenon



GREAT AUK IN MUSEUM AT AMIENS, FRANCE. FROM PHOTOTYPE.

GREAT AUK IN AMERICAN MUSEUM, NEW YORK CITY.

SMITHSONIAN GREAT AUK BEFORE REMOUNTING.

SMITHSONIAN GREAT AUK AFTER REMOUNTING.

—but Martin saw the birds. Sir William Jardine, in 1860, says the white spot is in front and around the eye, but his drawing shows he had not the courage of his conviction. However, Carpenter, in 1866, and Dallas, in 1867, took Jardine at his word, as appears from their illustrations of the bird. It is noteworthy that while nearly all the authors quoted describe the form of this spot as 'oval,' the photographs of mounted birds rarely show such an outline. This is owing to faulty taxidermy. A sub-triangular spot seems to have been the popular form with the majority, both of artists and taxidermists, in spite of the practical uniformity in description as to the oval shape. From the time of Brookes, in 1771, until a comparatively recent date, there has existed a strong desire to continue the spot under the eye, thus in a degree conforming to Martin's description in 1697. Audubon aimed to satisfy everybody, for in his swimming bird a white triangular spot continues under the eye while the 'large oblong white patch before each eye' of his standing bird conforms to his description.* Referring to the illustration of the Smithsonian auk, after remounting, it will be noted that the white spot is oval or elliptical in shape, with a comparatively even and regular outline, and this is believed to represent this characteristic marking of the species in its correct form and position. Any taxidermist can understand how a dried skin which has been softened unevenly might be stretched in such manner as to extend the margin of the spot outward in any direction, even under the eye, as in Audubon's swimming bird, or how an indentation could be produced such as appears on the front margin of the spot in his standing bird. Neither of these outlines, however, is tenable in the light of the evidence offered. The oval spot surrounding the eye can only be supported by an appeal to the offhand statement of Sir William Jardine, a statement which is disputed by every available fact.

Little need be said concerning the illustrations of the bill of the great auk, except that the outline in the majority is fairly good, although the representation of the grooves and their location on the bill appears to have been subject to speculative influences. The 'white grooves' of several authors should not be confounded with the white lines which appear crossing both maxilla and mandible in all published photographs. These lines are high-light lines due to light reflected from the elevated ridges above the grooves. An examination of the bills of mounted great auks shows that the grooves are a horn-white or whitish in the bottom, a shade much darker than the reflected light from the polished ridge would appear.

* The auks of Audubon accompanying this article were copied from the plate in the Library Edition of 1840 in which he says, regarding the illustrations—'the drawings on stone and the colouring, have also been well done and the former are almost all superior to the first numbers of the work, which I considered very good.'

THE MAKING OF BIOLOGISTS.

By Professor T. D. A. COCKERELL,
EAST LAS VEGAS, N. MEX.

IT is doubtless true that biologists are 'born' rather than 'made,' but it is probably no less true that they may be and are nipped in the bud in many instances by the frost of adverse circumstances. I speak of the making of biologists by the same right and in the same sense that the farmer speaks of raising crops, although as a matter of fact the crops raise themselves by their own inherent vitality. Encouraged by a lively conviction that the infant mortality of biological talent is much greater than is commonly supposed, I have sought to ascertain the conditions which permitted the survival of so much as we actually have, thinking that ways might be found to increase the crop. While neither expecting nor desiring that every one should become a specialist in biology, one may be pardoned for ardently wishing that the existing native talent should be more fully utilized, in view of the innumerable biological investigations lacking investigators.

In the United States to-day there are about four hundred publishing zoologists, exclusive of those whose writings are of little or no importance as contributing to the advancement of the science. The botanists are probably about as numerous, but I have not yet attempted to catalogue them. Of the zoologists about 140 are enumerated in 'Who's Who,' and these include most of those who have done any considerable amount of work, although there are some surprising omissions, and a few nearly as surprising inclusions. It would be a useful thing to publish at some future time a biographical index of all American biologists, living or dead, who have really contributed to the subject. In the meanwhile I have extracted a good deal of interesting information from 'Who's Who,' and a few other sources.

Starting with the idea that 'nature' counts for at least as much as 'nurture,' I looked for racial distinctions. Unfortunately it is impossible to ascertain the exact influence of race upon the development of talent, because those of different races are not subject to the same environment. It is well understood that the Germans, as a people, are inclined to be scientific, and considering the enormous influx of Germans into America, one would look for a large body of German-born biologists. There are, indeed, many German amateurs; but in our list of prominent American biologists the German-born are less than half-a-dozen, the best-known being Loeb, Ortmann and Eigenmann. Similarly, the Eng-

lish-born are scarcely worth mentioning; while Norway, Hungary, Switzerland and Canada have single representatives in Stejneger, Heilprin, A. Agassiz and McMurrich. On the whole, the foreign-born element in American biology is insignificant, and as it were accidental.

Such facts as these make us doubt the validity of the opinion that talent will always come to the front, whatever the conditions. Among those who have immigrated from Germany and the British Islands there must have been a larger number capable of biological research than the figures show; but as a matter of fact the conditions surrounding these people were not commonly favorable to scientific work. The same must be true of the French immigrants who settled long ago in the south; they have never yet shown anything like the scientific talent which their origin would lead us to expect.

Dr. G. B. Halsted told me last year that he believed that about one in two hundred persons in this country possessed some sort of mathematical genius. Being afterwards uncertain whether he meant university students or the general population, I wrote to him and received the following interesting reply:

> One in two hundred *university students* has marked mathematical ability. Of those who do not get to any university the percentage may be just as high, since only *race*, and not caste, is necessary for this gift. A Hindoo has just been senior wrangler at Cambridge, England; and Gauss was a bricklayer's son. No one with a drop of African blood has ever given us a theorem in mathematics. Shaler accounts for the stupidity of the Romans in mathematics by supposing that the primitive basal race in Italy was from Africa. There is a marked difference between ability in geometry and ability in arithmetic and algebra. The Jews give us more great mathematicians than any other race, but never a geometer. Geometry is hindered by a *necessity* for visualization. Todhunter said with penetrating wisdom that the person who had to see the relations definitely on a figure could not go on in the higher mathematics. Non-Euclidean geometry, my subject, cannot be visualized. Calculating prodigies are usually idiots, absolutely lacking in power of visualization. I enclose you a long account of one such [Jacques Inaudi] which is very definite on this point [*i. e.*, the absence of visualization]. Most eminent mathematicians are deficient as calculators, some do not know their multiplication table. . . . I have never in my life had to extract a root of a number. The thing which seems most to *foster* mathematical ability is use in very early youth, strong stimulation in early youth. (Litt., December 24, 1901.)

With respect to the negro race unfavorable conditions may have had more to do with unproductiveness than is supposed. The Tuskegee Institute under Professor Booker T. Washington has lately obtained the means of carrying on original research in science, and it will be extremely interesting to watch the results. I ventured to ask Professor Washington whether he had observed any scientific talent among his people, and he referred me to Dr. Roscoe Conkling Bruce, who wrote as follows on the subject of talented negroes:

Scientific aptitudes have to my knowledge appeared among the negroes not infrequently. Among negroes who have actually achieved a degree of eminence in scientific research are the late L. A. Willson, of Cleveland, Ohio; T. McC. Stewart, Jr., of New York city; Frederick Hemmings, of Boston; and Dr. S. C. Fuller, of Westboro', Mass. Dr. W. E. B. DuBois, of Atlanta University, has made two solid contributions to descriptive sociology, 'The Supression of the Slave Trade' and 'The Philadelphia Negro.' Dr. Kelly Miller, of Howard University, has made important mathematical researches. Professor Hugh M. Browne, of Baltimore, is an eminent physicist. Professor George A. Towns, of Atlanta, has written a valuable theory of æsthetics; Professor Ferris, of Cambridge, is now engaged in writing a book on metaphysics. Our Professor Carver, of Tuskegee, has done something in biology. There is frequently noticeable among our students at Tuskegee the scientific attitude and spirit. (Litt., April 6, 1902.)

It should be added that Professor C. H. Turner has done important work on fresh-water Crustacea.

Of course the custom of classing as 'colored' all those who have any negro blood makes it difficult to ascertain the possibilities of talent resident in the negro blood itself. I suppose that most of those above mentioned are of mixed blood, but I have no exact information.

Returning to our birth-statistics of zoologists, we may proceed to discuss the native-born. These people are the descendants of early immigrants who showed little or no scientific ability, doubtless for such reasons as we have already discussed. The tremendous increase of intellectual activity in Europe and America during the last century and a half shows what possibilities may lie unsuspected in a people; for no biologist can suppose that the stock itself has greatly changed in so short a period. The same may be said concerning the recent intellectual awakening of the Japanese, though no doubt these people formerly employed their minds in ways overlooked because unintelligible to Europeans. It seems wonderful to us to-day to receive monthly an entomological journal printed in Japanese and to find some of the best work in biology coming from natives of that country. Who knows but that we ourselves, great as has been our progress, are capable like the Japanese of yet other new births, into fields of intellectual activity hardly yet suspected to exist?

I have classified the native-born zoologists by the states of their birth. New York is easily in the lead, with Massachusetts a good second, Illinois third, Ohio fourth, Connecticut fifth. The more prominent names are as follows:

New York.—Beecher, Bigelow, Birge, Call, Casey, J. M. Clarke, O. F. Cook, B. Dean, J. Dwight, Dyar, Elliot, Gill, D. S. Jordan, Mearns, Merriam, G. S. Miller, Miss Rathbun, Shufeldt, Slingerland, J. B. Smith, Walcott, Ward, Whitfield, Winchell, J. B. Woodworth.

Massachusetts.—J. A. Allen, Beal, Brewster, Dall, Felt, Hitchcock, Lucas, C. D. Marsh, Minot, Scudder, Thayer, Thorndike, Williston. How few of these are to-day identified with Massachusetts!

Illinois.—Coquillett, Gilbert, Hatcher, L. O. Howard, Kofoid, Nutting, Ridgway, Simpson, Stanton, E. B. Wilson, Walcott.

Ohio.—Chittenden, Girty, Pratt, Schuchert, C. H. T. Townsend, Ulrich, C. M. Weed.

Connecticut.—Benedict, Blatchley, Davenport, C. L. Franklin, H. F. Osborn, Mrs. Slosson.

Pennsylvania has given us Ashmead, Bruner, H. C. Chapman, Garman, W. Stone and the late H. Strecker. From *New Jersey* we have Beutenmüller and F. M. Chapman; from *Maine,* Fernald, Verrill and C. B. Wilson; from *New Hampshire,* Nelson; from *Maryland,* Uhler. *Iowa* is the birth-place of Eastman, Evermann, McGee, Springer and Pilsbry; *Michigan* of V. Bailey; *Minnesota* of C. L. and C. J. Herrick; *Wisconsin* of H. Osborn, Ritter and W. M. Wheeler. The South is hardly represented at all; from *South Carolina* come J. A. Holmes and J. P. Smith; from *Kentucky,* Morgan and Miss Sadie Price; *Florida, Georgia, Louisiana, Arkansas, Mississippi, North Carolina* and *Virginia* do not appear on my list at all! There are, I hope, some zoologists born in these states of whom I have no statistics, but in any event the zoological output of the southern states is wholly insignificant. This fact suggests again the great influence of environment, whatever the blood; and one may add that the tropical English colonies have deprived us of the services of many a good man, who under more stimulating social and climatic conditions promised much.

The civilization of the West is so young that perhaps we ought not to expect much of the native-born therein. As a matter of fact, the showing is small indeed; my records give only these names: *Kansas,* V. L. Kellogg, Marlatt; *Texas,* Vaughan; *California,* T. S. Palmer. Of course there are many others less well known; indeed a very good crop of young men and women, who will be prominent enough in the next twenty years. Everything shows that California, in particular, will be the center of great biological activity; but so far Colorado is by no means doing her part. About fifteen years ago a small body of naturalists founded the Colorado Biological Association, of which the present writer was secretary; but the movement died in 1890, and to-day there are not enough biologists in the state to revive it or found a new society on similar lines. Even the professors in the state university seem to be permitted rather than encouraged to engage in research. However, Colorado has too much natural vigor to tolerate this inertia indefinitely; the time cannot be far distant when there will be an awakening.

I have also catalogued the prominent zoologists under the names of the schools, colleges and universities they attended; but the results are perhaps not very significant. Of course every one knows that many of our leading men (*e. g.,* Jordan, Dall, Uhler, J. A. Allen, Scudder) studied under Agassiz, but it may be doubted whether their interest in

biology was not fully determined before they went to him. I think it will be possible to show in due time, that the critical period for the biologist is much earlier than some of us have supposed, is, in fact, during the years of childhood. This would agree with Dr. Halsted's opinion, expressed above, about mathematicians. The list of those who received no university training is significantly long, including Ashmead, Beutenmüller, W. Brewster, F. M. Chapman, Cockerell, Coquillett, D. G. Elliott, Gill, Lucas, McGee, Miss Rathbun, Ridgway, Schuchert, Simpson, J. B. Smith, Thayer, C. D. Walcott, Whitfield and Uhler. On the other hand, Harvard, Johns Hopkins, Yale, Cornell, Amherst, Michigan and a few others have long lists of prominent graduates, and the list of those who studied in Germany is surprisingly large. In all, 56 institutions in the United States are represented in my list, mostly by only one or two names. There is plenty of evidence that first-class men may come from institutions which do not ordinarily turn out zoologists of any sort, or perhaps ordinarily do turn them out, in a different sense.

Dr. D. S. Jordan is the man who comes first into our mind as a gift from Agassiz. He himself is always ready to insist upon his obligations to that great naturalist; but the following information, kindly supplied to me by Dr. Jordan, shows that he was a good biologist before he ever saw the master.

> When a boy I lived on a farm in western New York. I was very early interested in the local botany and had made a collection of the local fauna before I entered college. At college I developed this as a thesis, called 'The Fauna of Wyoming County, New York,' for a master's degree. I was also very much interested in the breeding of sheep, and from my twelfth year to the time I went to college I gave considerable attention to this, having a pretty fair knowledge of all matters pertaining to a flock of sheep. Very soon after entering Cornell I was made laboratory assistant in botany, and was ultimately promoted to an instructorship. I did not take up zoology as a serious matter until after I had left Cornell. At Penikese I was instructor in marine botany. Agassiz thought that I ought to do some work of an entirely different sort, and placed me in charge of the work of collecting fishes, asking me to study the habits of the different forms. On going to Wisconsin—where marine botany is scanty—I was advised by him to take up the anatomy of fishes and especially of the ganoid forms. I did a good deal of work on birds, but deliberately chose fishes because the group was comparatively little known and apparently offered a wide field. The influence of Agassiz was a great element in my scientific progress. Not less great was that of Agassiz's student, Charles F. Hartt, several years ago professor of geology at Cornell—a subject in which I did a good deal of work. (Litt., October 25, 1901.)

It is perhaps by his general influence upon the country that Agassiz did most to promote the study of biology in America. Such a man always attracts to his person the enthusiastic young men who are able to benefit most by his teaching, but who would probably have made good biologists in any case. For most of these, the turning point had been

long ago reached and passed; but Agassiz was able to indirectly influence the young people of the whole country, and though he is now dead, he is not gone, and we are all in some sense his pupils.

Dr. Alfred R. Wallace, writing from Parkstone, Dorset, November 7, 1901, has given me the following most interesting account of his early experiences:

> As to my interest in biology, I can trace it I think to two very trifling facts. I doubt if I had or have any *special* aptitude for it, but I have a natural love for *classification* and an inherent desire to *explain things*;—also a great love of beauty of form and colour. The two slight facts are these. When a boy at school I heard a Quaker lady say that she and some friend had found the 'Monotropa,' which was quite a discovery as being before unknown in the district. This, and hearing the names of other flowers referred to as rare, made me think it would be very interesting to know the names of all the plants that grew wild,* but as I had no botanical friends the wish remained dormant, till I was about 15, when I purchased for a shilling (I think) a little book on botany published by the *Society for the Diffusion of Christian Knowledge*, and which contained the characters of about a dozen of the commonest natural orders in Britain. This was a revelation to me, and kept me employed for a year or two determining the flowers I met with if they belonged to any of these few orders. I then bought Lindley's 'Elements of Botany,' I think it was, but was disappointed in finding no more 'orders' described, but details of structure which did not much interest me. When recovering from a serious illness I met with Loudon's 'Encyclopædia of Plants,' and finding that this contained brief characters of all British plants, I amused myself by copying them *all*, except I think the grasses and sedges, on sheets of note paper, which I interleaved in Lindley's volume, and by means of these I was able to determine most of the species I met with, and made a considerable herbarium. The other incident was, meeting H. W. Bates at Leicester and being started by him as a beetle and butterfly collector. The enormous *variety* of form and structure in the beetles attracted me, and I think during all my tropical experiences the collection of these gave as much enjoyment as even the gorgeous birds and butterflies. Classification then began to fascinate me, through Swainson, and the 'Vestiges of Creation,' with the works of Herbert Spencer, started me on the problem of the origin of species; and thus my various mental tendencies had full occupation in the contemplation and study of natural objects. I also, very early, became interested in geology, in mechanics, in physics and in astronomy, and this breadth of scientific interest, though with no direct education in any one of them, has been of great service to me in preventing a too exclusive attention to any one aspect of nature.

With reference to Dr. Wallace's disclaimer at the beginning of his letter, it may be questioned whether there is such a thing as a special aptitude for biology, aside from the combination of just such tastes and aptitudes as he describes. I have always fancied that the same qualities which would make a good historian would make also a good biologist—the interest in living things, the love of detail and of classification, the fidelity to truth, the perseverance in inquiry, the lively imagination, and

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*I also heard, to my astonishment, that every minutest *weed* had been described and had a name.

so forth. It is interesting in this connection to note that the ornithologist Coues became a historian during the last years of his life. The love of beauty is also undoubtedly a strong factor in the making of biologists, although there are some good workers who seem to be singularly deficient in this respect.* Many years ago the present writer went with Dr. and Mrs. Wallace to find the daffodils in an English meadow. When we arrived at the place, we found the flowers in profusion, and it was inspiring to see the child-like pleasure the veteran naturalist took in their beauty. Here was a man who could never grow old, to whom nature was a perpetual delight. As I heard Professor C. L. Herrick say in an address to some students, the love of nature is the secret of perpetual youth.

In the first issue of *The Hibbert Journal,* Sir Oliver Lodge writes as follows:

> Take a scientific man who is not something more than a scientific man, one who is not a poet, or a philosopher, or a saint, and place him in the atmosphere habitual to the churches—and he must starve. He requires solid food, and he finds himself in air. . . . Take a religious man, who has not a multitude of other aptitudes overlaid upon his religion, into the cold dry workings, the gropings and tunnellings of science, where everything must be scrutinized and proved, distinctly conceived and precisely formulated,—and he cannot breathe.

I think this antithesis is not altogether a natural one, but that, on the contrary, the scientific man *must* be something of 'a poet, or a philosopher, or a saint,' to be completely a scientific man. It will be a sad day for the world when we cease to have men who can live freely in the enjoyment of the universe, and each one is permitted to know only this or that. Let us be free to think and enjoy, even though our thoughts wander far afield, and our enjoyment is not always that of a connoisseur.

Sometimes science suffers greatly in the opinion of those who do not claim to be scientific, just because her proper character is not understood, and it is assumed that she must be cold, hard and unimaginative. I have heard the late William Morris speak contemptuously of science, and in his admirable lecture on 'The Aims of Art' (1887) he says that if socialism does not prevail 'science will grow more and more one-sided, more incomplete, more wordy and useless, till at last she will pile herself up into such a mass of superstition, that beside it the theologies of old time will seem mere reason and enlightenment.' Yet Morris was himself an admirable observer of nature, and possessed many of the best qualities of a naturalist. I suppose the name of psychology would have

* I heard the other day a perfectly authentic story of a teacher in one of our best universities, a man who has done wonderful work in classification, and is far ahead of all others in his particular specialty. One of his students, looking through the microscope, exclaimed at the beauty of some object. The professor immediately shut him up with the remark: 'I should think that by this time you would know that you don't come here to look at pretty things!'

made him shudder, and yet the very lecture cited is really an important contribution to that subject, with its theory of the moods of energy and idleness. The views just expressed seem to be confirmed by the history of one of the most distinguished biologists of this country, Dr. A. S. Packard, who writes me as follows:

> I may say that the love of flowers, animals and natural scenery was inborn in me. My ancestry on both sides were ministers, we never had a naturalist in the family, but my father was extremely fond of and appreciative of natural scenery, and was interested in history and archæology. As a child I was very fond of flowers, as were my parents, and as early as I can remember had a flower-garden of my own. When about 14–15 I began to collect minerals, and then shells. My zeal for collecting and forming a museum led an older brother, who also had such tastes, to give me his cabinet, containing curiosities, shells and minerals. I was also an omnivorous reader,—devoured all the books on natural science in the library of Bowdoin College, where I was kindly allowed to browse, long before entering college. When about 16–17 I collected insects in considerable numbers. I was also aided by a maiden lady in Brunswick, Maine, who told me about shells, and aided me in naming my native plants. I formed a herbarium before entering college. From Miss Ann Jackson when a boy I first heard of Lamarck, and of his classification of shells, and of the Lamarckian genera of shells. With, then, an inborn taste for natural history, an aversion to business, and a fondness for books, my deep interest in animal life was sustained and I was impelled to devote my life to biological study. All through college I corresponded with Professor Baird, assistant secretary of the Smithsonian Institution, also with conchologists and entomologists, and this was a constant stimulus to the natural zeal and interest, or passion, for biology which has influenced my life. Also I was a born collector, though I have now no large collections. I trust this will show how I became interested in natural history. Had I been brought up in a city, the result might have been different. (Litt., October 28, 1901.)

It is interesting to think that Packard might have been our leading conchologist, Jordan our first authority on seaweeds. In nearly every case of which I have full information, some other branch of biology was studied than that which afterwards became the specialty. The interest was almost always at first a general one, afterwards limited by circumstances or choice. Of course one has to remember here that nearly all children in rural districts are interested in nature, though so few become biologists. The writer spent part of his childhood on a farm in Sussex, England, and well remembers the interest taken by the children in the first primroses or daffodils of the year, the arrival of the birds, the occurrence of efts (newts) in certain ponds, and such matters. It seems probable that most children are potential biologists, to some extent, but only a few are able to break through the crust of indifference and opposition which surrounds them a little later, and remain naturalists to the end. If this is true, and it is also true that stimulation at an early age is very important, the nature study movement in the schools may yet produce great results for science. However, in the absence of suitable teachers,

and in view of the crowded curriculum and consequent weariness of the pupils, one fears that in many instances the effects of a nature study course may be the reverse of those desired. There may be fatigue and disgust with the whole subject.*

Most of the naturalists who have kindly written me about their early life state that their interest began in the woods and fields—anywhere but in the town. It would seem that the chances are very much against a naturalist born in the city, notwithstanding certain presumed advantages in the way of education.† A good typical instance of the influence of country life is given by Dr. John M. Coulter, the well-known botanist, who writes:

> I was brought up in a village and had a strong out-of-door tendency. This took me into the ravines, and woods, and along the streams in the neighborhood almost constantly. My interest for collecting things runs back to a time I cannot recall. The actual selection of botany among other out-of-door subjects was probably determined by the lines of least resistance, in the form of opportunities presented. (Litt., October 24, 1901.)

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* Many an English boy has acquired a distaste for the Bible from having to learn chapters by heart, lists of the kings of Israel, and so forth; and this often on Sundays, depriving him of the rest and recreation to which he feels entitled.

† One thing in favor of the city is the museum, where it exists. It is undoubtedly a factor of great importance, as will be shown later on.

THE RELATION OF MALARIA TO AGRICULTURE AND OTHER INDUSTRIES OF THE SOUTH.

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IN a paper on 'Measures for the Decrease of Malaria in the South,' read in Nashville, Tenn., in August of the past summer before the Southern Commissioners of Agriculture, I very briefly called attention to the important rôle of malaria in agriculture. It was an inadequate attempt to demonstrate the practical bearing of this disease upon the wealth-producing powers of a commonwealth, with the hope that it might prove an added inducement for putting into practice the measures which had been recommended for the decrease of malaria. For to induce a people to use a remedy it must first be shown that a remedy is very much needed. We trust that this further treatment of the same question will result in more widespread and serious discussions and investigations of the profound influence of this most insidious disease upon the industries and wealth-producing powers of the southern people.

The south as a whole has given little thought to the tremendous rôle malaria plays in her industries, especially in agriculture. We have no idea of the loss occasioned by malaria in unfitting men for long or energetic hours of labor. The loss of energy and enthusiasm, the loss of interest in one's own efforts and successes, all of which contribute enormously to the inefficiency of labor and cause the wealth-producing power, especially in agriculture, to fall far short of its normal capacity, is due in a marvelous and undreamed of degree to that life-sapping disease, malaria. The man that is just able to 'crawl out of bed and drag around' is certainly not the man to accomplish an efficient and full day's labor. Because a man is at work is not necessarily a proof that he is actually adding to the sum total of his own wealth or to that of the state, and in a lesser degree does it prove that he is adding to the sum total of wealth, all of which he is capable. A man's general state of health has quite as much relation to his producing powers as the amount and kind of food he eats. And certainly there is no disease known to man that more insidiously undermines his constitution and lessens his ability to produce his full measure of wealth than malaria. Moreover, looking at malaria from another point of view, namely its relation to other diseases, let us hear what the eminent Dr. Patrick Manson, of England, says. In speaking of the importance of our knowledge concerning the relation of mos-

quitoes to malaria he says: 'This is a piece of knowledge of the utmost importance to mankind, for we know that malarial disease in tropical countries . . . *causes more deaths and more disposition to death* by inducing cachectic states, predisposing to other affections than *all the other parasites affecting mankind together.*' The italics are our own. This is a most startling statement to the ordinary layman, yet it comes from one who knows whereof he speaks.

Celli, the celebrated Italian authority on malaria, tells us that the mean mortality statistics give about 15,000 deaths yearly from malaria in Italy. He further says that, "calculating from the number of deaths the number of patients, we arrive approximately at about two million cases a year." "The loss of labor and of production, and the expenses entailed in dealing with this disease consequently amount to several millions of francs." About five million acres of land go uncultivated or very improperly cultivated, which represents an enormous loss. One railway company spends on account of malaria one million fifty thousand francs ($200,000) a year. He sums up by saying, 'one can positively assert that *malaria annually costs Italy incalculable treasure.*'

Our own statistics on malaria are meager and not so clear cut as one could wish. Yet the figures of the twelfth and last census which is just now appearing are enlightening, as the following table taken from that census will show. I have selected the six diseases that cause the most deaths in the states considered. There are no other diseases that approach near enough to these in their death rate to demand serious consideration or comparison.

NUMBER OF DEATHS FOR YEAR ENDING MAY 31, 1900.

	Total.	Consumption.	Heart Disease.	Pneumonia.	Typhoid.	Dysentery.	Malaria.
Louisiana.....	20,955	2,016	1,149	1,945	1,077	385	1,030
Mississippi....	20,251	2,129	876	2,168	1,370	380	983
Alabama.....	25,699	2,666	1,111	2,459	1,713	864	1,005
Georgia.....	26,941	2,651	1,350	2,598	1,585	781	1,011
South Carolina	17,166	2,133	843	1,324	970	578	749

It must be borne in mind that these figures concern only those deaths that were reported. Scores of deaths occurred in these states that were never reported. But it no doubt is safe to assume that the deaths from one disease were reported as fully as those from another, hence we can with fairness use these figures for making comparisons.

In the first place then, considering malaria by itself in relation to the total number of deaths in each of the five states mentioned, we find the following generalizations to be true. The total number of deaths in Louisiana for the year ending May 31, 1900, was 20,955, of which 1,030 or very nearly one twentieth were from malaria fevers. In

Mississippi for the same year there were 20,251 deaths, of which 983 or a trifle less than one twentieth were from malaria fevers. In Georgia, Alabama and South Carolina, taking these three states as a whole, a trifle less than one twenty-fifth of the whole number of deaths was due to malaria. Evidently then malaria is responsible for a surprisingly large part of the whole number of deaths in these five states.

But there is another and much more significant fact to be drawn from the afore-mentioned table. It is seen that, in general, consumption, heart disease, pneumonia and typhoid fever caused more deaths than malaria and these were the only diseases that did. But these diseases are much more fatal than malaria. That is, where one person sick with either of these four diseases recovers, dozens are sick with malarial chills and fevers and recover. In other words, malaria causes much more sickness than any one or all of those four diseases rolled in one. Taking Celli's own basis of estimate, we shall find that there were in the five states mentioned, approximately 635,000 cases of malaria in the year ending May 31, 1900, a factor truly appalling in its influence against the wealth-producing power of a people.

Again we must just here take into consideration the fact that the census figures do not give an accurate and full report of all the deaths by malaria. This is an important point because where one death from malaria is not taken into account a dozen or more cases of sickness from chills and fevers are not accounted for, whereas when one death by consumption is not reported, it is simply one death not reported and nothing more. The same is largely true of the other three diseases used in our comparison. There is not a doubt that the cases of sickness as a result of malaria would easily number a round million could we obtain full and accurate reports.

Finally by taking all the foregoing facts and deductions into consideration, we are forced to but one rather startling conclusion, namely, that *malaria is responsible for more sickness among the white population of the south than any disease to which it is now subject.*

We must now consider briefly what six hundred and thirty-five thousand or a million cases of chills and fevers in one year mean. It is a self-evident truth that it means well for the physicians. But for laboring men it means an immense loss of their time together with the doctor's fees in many instances. If members of their families other than themselves be affected it may also mean a loss of time together with the doctor's fees. For the employer it means the loss of labor at a time perhaps when it would be of greatest value. If it does not mean the actual loss of labor to the employer, it will mean a loss in the efficiency of his labor. To the farmers it may mean the loss of their

crops by want of cultivation. It will always mean the non-cultivation or improper cultivation of thousands of acres of valuable land. It means a listless activity in the world's work that counts mightily against the wealth-producing power of a people. Finally, it means from two to five million or more days of sickness, with all its attendant distress, pain of body and mental depression to some unfortunate individuals of those five states.

While the above statistics are meager and inconclusive, and while our estimates may be open to question, yet we may be sure that malaria detracts enormously from the full wealth-producing power of the south. To substantiate this statement one has but to reflect, from his own personal knowledge, upon the number of working days that are lost in a year by white men because of chills and fevers. The writer recalls to mind many such cases within the year. Only the past summer I saw a whole family forced to leave a farm on account of malaria. While living there some one or all of them were sick the major portion of the time, and although the farm was a productive one they were scarcely able to make a living, because of their unfitness for work. In a certain railroad town with which I am familiar it is invariably the rule that some employee is 'laying off' because of chills and fever or because of some indisposition at the bottom of which is malaria.

In my summer vacation which was spent in North Carolina I had an opportunity of observing a laboring man and his family that lived near a brook in the quiet pools of which were the malarial mosquitoes, *Anopheles*. During my sojourn of about three weeks the head of the family 'laid off' four days from chills and fevers, and no doubt he has lost many days since during the autumn. He is a man with a delicate, pale skin and, while conversing with him, I have noted as many as two *Anopheles* mosquitoes on one hand at the same time. The question has often occurred to me since, whether these mosquitoes prefer to attack people with delicate skin. My own face and hands were not troubled by them, although we stood within hand-shaking distance of each other and the mosquitoes were fairly abundant. The mother and children of the family were great sufferers from malaria, especially the former, on account of which much of their earnings was used to pay doctor's fees.

In looking for a concrete effect of malaria upon agriculture, we have only to turn our attention to one of the most fertile regions of the United States if not of the world, namely, the so-called Delta region of Mississippi. It lies along the Mississippi River in the western part of the state and extends from the mouth of the Yazoo River north, nearly to the Tennessee line. It is the second best farming land in the world, having only one rival, and that is the valley of the Nile. Still this land to-day, at least much of it, can be bought at ten to

twenty dollars an acre. Thousands of acres in this region are still covered with the primeval forest, and the bears and deer still roaming there offer splendid opportunities for the chase, as evidenced by the late visit of our chief executive to those regions for the purpose of hunting. Why is not this land thickly settled and why is it not worth from two to five hundred dollars an acre? If it produces from one to two or more bales of cotton on an acre, and it does, it ought to be worth the above named figures. A bale of cotton to the acre can be produced for thirteen dollars, leaving a net profit of twenty to forty dollars for each bale or forty to eighty or more dollars for each acre of land cultivated. Moreover, this land has been doing that for years and will do it for years to come without the addition of one dollar's worth of fertilizer. Land that will produce a net profit of forty to eighty dollars an acre is a splendid investment at one, two or even three hundred dollars an acre. Yet this land does not sell in the market for anything like so much, because the demand is not sufficient, for white people positively object to living in the 'Delta' on account of malarial chills and fevers. A man said to me not long ago that he would go to the 'Delta' that day if he were sure that his own life or the lives of the members of his family would not be shortened thereby. There are thousands exactly like him, and the only reason that these thousands do not go there to buy lands and make homes is on account of chills and fevers. But there is a time coming, and that not far distant, when malaria in the 'Delta' will not menace the would-be inhabitants. When that time comes it will be the richest and most populous region in the United States.

There can be no doubt that many people are kept away from the sunny southern skies because of the dangers of malaria, sometimes fancied 'tis true, but quite as often real. It behooves us to remove this danger entirely. I feel sure the day is soon coming when chills and fevers will have lost their terrors because we shall surely learn how to avoid them. It is most propitious that these wonderful discoveries in regard to malaria and yellow fever were made on the eve of the south's great awakening along industrial and educational lines.

If the experiments of Ross, Manson, Celli, Sambon, Low and others demonstrate that malaria can be avoided; and if the experiments of Carroll, Reed, Lazear and Agramonte demonstrate that quarantine and fumigation are useless and that yellow fever can be controlled by controlling mosquitoes or by keeping inside of a wire screen out of their way, then I venture to predict that those experiments will go down in the annals of the south as the most important of the nineteenth century.

THE HABITS OF THE GIANT SALAMANDER.

By Dr. ALBERT M. REESE,
SYRACUSE UNIVERSITY.

CRYPTOBRANCHUS (*Menopoma* of the earlier text-books) *Alleghaniensis* or hellbender, the American representative of the giant salamanders, although only too familiar to the fishermen of the Ohio valley is, to most people, rather a curiosity and its habits, therefor are worthy of some attention.

Its distribution, according to most authors, is limited to the tributaries of the Ohio River, but whether or not this is strictly true I am unable to state. I have investigated several cases of the supposed occurrence of *Cryptobranchus* in waters far distant from the Ohio, but in each instance the animal in question proved to be *Necturus*. By the natives of the regions it inhabits, the hellbender is called 'alligator' or, occasionally, 'waterdog': it is easy to imagine how the former name might have originated, but why it should be called a 'dog' is as hard to imagine as the reason for calling *Necturusa* 'mud-*puppy*.' The hellbender is said to reach a length of more than 60 cm., the largest specimen that I obtained, from a considerable number of individuals, was 55 cm. in length. It is a most unprepossessing animal, and, probably on that account, has the reputation, among fisherman, of being poisonous, although it is really a most inoffensive and harmless creature. I have handled many dozen individuals, some of which were just from their native stream and some of which I have had in captivity for more than eight months, but in no instance has any attempt been made to bite. Its jaws are very wide and strong, however, and being armed with numerous small, sharp teeth, are probably capable of inflicting a painful wound. Its repulsive appearance seems to be largely due to the curious flatness of the head, the tiny, almost invisible, lidless eyes and the lateral folds of skin which extend for the greater part of its length.

The tips of the toes, of which there are four on the anterior and five on the posterior feet, are nearly white and are thus in curious contrast to the dark color of the rest of the animal.

The adult hellbender breathes by means of well-developed lungs, but there is a gill opening in each side of the throat, from which bubbles of air occasionally escape. The nostrils are two very small openings situated at the extreme tip of the broad snout, so that when the animal comes to the surface to breathe, it need expose but the tip of its snout above water. The process of inspiration, if it may be so called, is

practically one of swallowing air. When it becomes necessary for the hellbender to take in a fresh supply of air, it swims towards the surface of the water until the tip of the snout is exposed; then, by swelling downward the skin of the floor of the mouth, a huge mouthful of air is drawn in, and the animal, now arching upward its neck and back, slowly sinks to the bottom, the swallowed air passing back to the lungs either by its own buoyancy, the lungs now being higher than the throat, or by a sort of peristaltic action of the throat. As the animal sinks, a considerable portion of the air that was taken into the mouth escapes through the nostrils or through the gill openings. After reaching the bottom, the animal frequently retains, for some time, the strongly arched position, as though the region of the lungs were buoyed up by the air that had just been taken in. The air is gotten rid of partly by a quick expiration when the animal comes to the surface, and partly by an occasional bubble sent up from the bottom. If the animal be alarmed as by a sudden approach to the tank in which it is contained, it frequently sets free one or more large bubbles of air, perhaps by the involuntary relaxation of certain muscles, perhaps by a voluntary expulsion of superfluous air, to enable it better to escape the supposed danger. The length of time that the hellbender remains under water seems, in captivity at least, to be quite variable. I made a series of observations on three individuals, a very large one, a very small one and a medium-sized one, and the average interval between inspirations was about fifteen minutes. The longest time that any individual was actually observed to remain below the surface was forty-three minutes.

In motion the hellbender is usually slow and awkward. On a smooth dry surface, as the top of a table, it is almost helpless, because the slime secreted by the skin soon dries and becomes so sticky as almost to prevent motion. Even in its native element its motions are usually awkward, though when swimming rapidly this is not apparent. In crawling over the bottom, the diagonally opposite legs very nearly 'keep step,' *i. e.*, the left front leg and the right hind leg move forward at the same time. In active swimming the tail is the most effective organ, as in the alligators. If an individual, which is lying quietly on the bottom, be watched carefully it will frequently be noticed that it has a slight rocking or swaying motion, caused by the alternate straightening or relaxing of the legs, similar, perhaps, to the swaying motion of elephants. In captivity they usually congregate in the darkest portions of their tank, crawling under boards or stones if these be present, or under each other if there be no better hiding place. If not lifted above the surface of the water, they may be handled with scarcely a struggle, but if taken from the water they struggle to regain their native element. As a rule the smaller specimens were more active than the larger.

As my chief object in collecting the hellbenders was to obtain eggs for embryological work (my hope being that the animals would spawn in captivity) and as I had at first no idea as to when the spawning season occurred, I started in pursuit of the creatures about the first of February, tramping many weary miles through three feet of snow and chopping numerous holes through the thick ice that covered French Creek in which the hellbenders abound. Hand-lines, night-lines and traps were tried again and again, but, though several specimens of *Necturus* were caught, not a single *Cryptobranchus* was obtained until the twenty-eighth of March, after the ice and snow had all disappeared and several days of warm weather had slightly warmed the water. Fishermen, generally, stated that 'alligators' could not be caught until the ice had melted and the water had had time to warm slightly.

Although the first specimens were caught during the last days of March, it was not until nearly a month later that they could be obtained in any numbers, and it was during May that they were most abundant. About June 7, desiring to obtain a few more specimens, I applied to the boys from whom I had been buying them, but, after fishing for a week or more, they told me that the 'alligators' had stopped biting, and I was unable to obtain the additional specimens that I wanted. Whether they usually cease taking food at this time I am unable to say, but Mr. Chas. H. Townsend, of the New York Aquarium, says* that they were caught by him in August, on hooks baited with pieces of meat or fish heads. Most of the specimens I obtained were caught in traps that had been set for fish, though many were caught with hook and line, the disadvantage in the latter method being that the hook was often caught so far down in the digestive tract that it could not be extracted without seriously injuring the animal.

The color of all the hellbenders, when first caught, was a more or less uniform dirty black or greenish-brown with numerous irregular dark spots on the dorsal side. Fishermen were occasionally heard to speak of 'red alligators' but I never saw a hellbender that could, in truth, be called red, though after they had been in captivity for a couple of months many of them changed color very perceptibly, becoming a more decided brown, sometimes with a decided greenish tinge and sometimes with the dark spots, mentioned above, very pronounced. It is possible that this change in color, in a state of nature, may be very much more marked and that when the breeding season arrives it may become an actual red, and serve as a sexual character. Judging from analogy, it would be supposed that these more brilliantly colored individuals would be males, but such was not the case. Of the specimens that I had under observation, nearly all were females; if this were true in a state of nature, it might be possible

* *American Naturalist*, February, 1882.

that the females had acquired this brighter coloring, as a secondary sexual character, for the attraction of the males.

The hellbender has the reputation of being an exceeding voracious animal, and in his native stream this is probably true, though in captivity his appetite is very moderate. The contents of the stomach of a number of individuals were examined, and it was found that the most common article of food was apparently crayfish, though earthworms, small fish and, in one case, the mandibles and a foot of a small mammal, probably a mouse, were found. Fish as much as 8 cm. in length were sometimes found in the stomachs of large individuals. As it seemed impossible to catch the hellbenders until comparatively late in the spring, it is probable that they lie dormant through the winter, and hence do not take any food until they renew their activity at the appearance of warm weather.

A number of animals that I obtained one morning in a fish-trap seemed very much distended, as with eggs; on being put into a tub of water they disgorged a great mass of material consisting chiefly of a number of small fish that had been caught in the same trap and had thus fallen easy prey to the appetite of the hellbenders. It almost always happened that when hellbenders were put into an ordinary vessel of water they disgorged, within a few hours, the contents of their stomachs, while if put into a tank of *running* water they seldom, if ever, disgorged.

Although it seems certain that they catch and eat living fish and crayfish, under natural conditions, they never ate these animals alive in captivity nor, as far as I could see, ever attempted to catch them when they were put into the tank and left there for days. The fact, however, that the crayfish were frequently found on top of a floating piece of board that was in the tank would seem to indicate either that the hellbenders had attempted to catch them or that they had an instinctive fear of the salamanders, founded on racial experience. A couple of small hellbenders were kept for a short time in a glass aquarium jar for close study. These two individuals were the only ones that were actually *seen* in the act of taking food. If earthworms were lowered into the water just in front of them, they would seize them by a quick, lateral jerk of the head and then swallow them by a series of quick forward jerks, the tongue being, apparently, of very little use in drawing food into the mouth. The quickness of this seizing motion was quite surprising in so sluggish an animal, and showed how a fish or crayfish that ventured within reach might easily be captured. From the beginning of their captivity the hellbenders were fed on raw liver, chopped into pieces as large as the end of a man's thumb. During the first few weeks they ate very little and were fed about once a week, but

towards the last of July their appetites seemed to increase, and they were fed every two days. They would never eat, as has been said, while they were watched, but if the liver were left in the tank over night, most of it would be eaten before morning.

The extreme slowness of their digestion is shown by the fact that liver eaten seventy hours before, on being disgorged showed very little change, the pieces being of about the same size and consistency as when swallowed.

After about the middle of September, the hellbenders refused to eat during a period of more than two months, though pieces of liver were put into their tank at intervals. One morning at the end of this period, on looking into the tank, something black was seen projecting from the mouth of one of the largest hellbenders, which on close examination proved to be the end of the tail of the smallest of the hellbenders, which had been swallowed head-first. By means of a pair of forceps the smaller individual was withdrawn from within the larger, and both immediately swam away, none the worse apparently for their remarkable experience. The smaller hellbender was a little more than half as long as the one by which it was swallowed. In spite of this apparent return of appetite, the hellbenders ate but little of the fresh supply of liver that was immediately given them.

The remarkable vitality of the hellbender is well known by those who have had any opportunity of studying the living animal. Mr. Townsend in the article mentioned above says: "They are remarkably tenacious of life. I carried my specimens six miles in a bag behind me on horseback, under a blazing hot sun, and kept them five weeks in a tub of water without a morsel to eat, and when I came to put them in alcohol they seemed almost as fresh as ever."

I had several illustrations of their tenacity of life. One of the first specimens I obtained, a large one, more than 50 cm. in length, escaped from the tank into which it had been placed and hid itself under a lot of lumber and rubbish that was piled near by. After a long search it was given up for lost, but one morning, just a week later, on going into the cellar where the tank was kept, there lay the escaped hellbender, dry and dusty but as well as ever, and the same animal is living at the present time. Some months later, while they were living in a tank of running water in the back yard of a city house, another hellbender escaped and could not be found. Exactly three weeks later it was found lying on the pavement outside of the yard. It was still living, though extremely thin and weak, but it died a few hours after being put back into the tank, possibly because it was too weak to swim to the surface for air. During the three weeks it was lost it changed color very decidedly, becoming a reddish-brown, with the dark spots showing in sharp contrast. During the latter part of June sixteen hellbenders,

nearly all of large size, were put into a wooden box (12 in.× 9 in.× 6 in. in size) in which numerous small holes had been bored and were taken from western Pennsylvania to Baltimore, Maryland. Although confined in such small space for a continuous period of nineteen hours, they reached the end of their journey in perfect condition. On another occasion fifteen of these same animals were put into the same box and taken by rail to a distant city; on this occasion they were in the box continuously for twenty-five hours, and one individual died on the journey, apparently suffocated by the mass of disgorged liver that filled its mouth. I had purposely refrained from feeding them for several days previous to the journey, but their fast had not been sufficiently long and the undigested liver was all disgorged, apparently causing, as has been said, the death of one individual.

Although possessed of such tenacity of life their recovery from wounds is apparently slow, a wound in the head of one large specimen remaining raw and open for several months. Possibly in its natural environment recovery would have been more rapid.

My chief aim, as I have said, in working with *Cryptobranchus,* being to obtain embryological material, I enquired of every fisherman and countryman I met, and of many other people as well, concerning the breeding habits of this little-studied animal. The only facts of any sort that I could learn were obtained from Mr. C. H. Townsend, whom I shall again quote. He says in the article mentioned above: "During their confinement in the tub two of the females deposited a large amount of spawn. This spawn was something similar to frog spawn in its general appearance, but the mass had not the dark colors of the latter. The ova were exuded in strings and were much farther apart than frog eggs. They were of a yellow color, while the glutinous mass which connected them had a grayish appearance." This deposition of spawn, he says, took place in August. Had I had this information earlier in the season it would have saved me many fruitless attempts to capture the hellbenders, and possibly my efforts to obtain their eggs might have been successful. As it was I did not get a single egg, the animals refusing to spawn in captivity, though they were kept in a large tank of running water under conditions as near like their natural habitat as I could make them.

Ovaries examined during the first two months showed a gradual development, but those examined during the early part of September showed evident signs of degeneration. All of the individuals killed, except one or two, were females. It would seem that hellbenders, like some other amphibia, will not spawn in captivity if removed from their natural environment too long before their natural breeding season.*

* The author has in preparation a paper on the anatomy and histology of *Cryptobranchus,* which he hopes to have ready for publication in a few months.

THE CARNEGIE INSTITUTION AND THE NATIONAL UNIVERSITY.

By Professor JAMES HOWARD GORE,
COLUMBIAN UNIVERSITY.

THE recent gift of Mr. Carnegie for the founding 'in the city of Washington, in the spirit of Washington, an institution which, with the cooperation of institutions now or hereafter established, there or elsewhere, shall, in the broadest and most liberal manner, encourage investigation, research and discovery, encourage the application of knowledge to the improvement of mankind; provide such buildings, laboratories, books and apparatus as may be needed, and afford instruction of an advanced character to students whenever and wherever found, inside or outside of schools, properly qualified to profit thereby' has awakened unprecedented interest in the educational world.

There has been no lack of persons ready to criticize the purpose of the institution and the methods by which the avowed purpose is to be carried out. And this criticism has not always been favorable.

That it should be located in Washington, is acceptable to all; that the 'spirit of Washington' should be observed in formulating the lines of activity meets with universal approval. But there are many who feel competent to expound the 'spirit of Washington' and stand ready to measure the new institution by the standard derived from their interpretation of this spirit.

Those who have dreamed of a national university, who have looked upon education as a function of the general government and saw in such a university the culmination of a general educational system—ignoring the anomalous condition of state supervision of the schools up to the state university and in some instances only including the state university, with a higher institution over and above all—such persons declared that the directing forces of the Carnegie Institution have not caught the 'spirit of Washington.'

The workers for a national university have appealed to our patriotic affection for Washington by quoting from his will these words:

> I proceed after this recital, for the more correct understanding of the case, to declare; that, as it has always been a source of serious regret with me, to see the youth of these United States sent to foreign countries for the purpose of an education, often before their minds are formed, or they had imbibed any adequate ideas of the happiness of their own; contracting too frequently, not only habits of dissipation and extravagance, but principles unfriendly to re-

publican government, and to the true and genuine liberties of mankind, which thereafter are rarely overcome; for these reasons it has been my ardent wish to see a plan devised on a liberal scale, which would have a tendency to spread systematic ideas through all parts of this rising empire, thereby to do away local attachments and State prejudices, as far as the nature of things would, or indeed ought to admit, from our national councils. Looking anxiously forward to the accomplishment of so desirable an object as this is (in my estimation), my mind has not been able to contemplate any plan more likely to effect the measure, than the establishment of a University in a central part of the United States, to which the youths of fortune and talents from all parts thereof may be sent for the completion of their education, in all the branches of polite literature, in arts and science in acquiring knowledge in the principles of politics and good government, and as a matter of infinite importance in my judgment, by associating with each other and forming friendships in juvenile years, be enabled to free themselves in a proper degree from those local prejudices and habitual jealousies which have just been mentioned, and which, when carried to excess, are never-failing sources of disquietude to the public mind, and pregnant of mischievous consequences to this country. Under these impressions so fully dilated,

Item.—I give and bequeath in perpetuity, the fifty shares which I hold in the Potomac Company (under the aforesaid acts of the Legislature of Virginia) towards the endowment of a University, to be established within the limits of the District of Columbia, under the auspices of the general government, if that government should incline to extend a fostering hand towards it.

(Signed July 9, 1790.)

An analysis of this will shows that its author advocated the breaking down of local attachments and prejudices by stimulating a love for the nation and bringing together youths from all sections; that he wished to keep the young men in this country instead of encouraging them to go abroad—two propositions that are somewhat antagonistic, since the one seeks to broaden students by eliminating state lines, the other to keep them narrow by erecting national barriers. Furthermore, this eradicating of 'habitual jealousies' was to be accomplished by 'the establishment of a University in a central part of the United States,' and it will be noticed that later on, by implication, he defines this central part to be 'within the limits of the District of Columbia.' It therefore seems that the correct standpoint from which to appreciate the 'spirit of Washington' is the date when the 'District of Columbia' was the 'central part of the United States,' and the welfare of the nation depended upon isolation and intellectual training by domestic talent rather than foreign culture. At this date, what could have been Washington's ideal of a university course of study? Could it have been far beyond the curricula of the colleges then in existence? An examination of the courses of study at that time available would determine what a national university should offer unless it be asserted that this spirit, so frequently referred to, could grow with the country while the arguments for intellectual unification inwardly and insularity outwardly should continue in force.

At the date when this will was signed, July 9, 1790, the following colleges were in operation in the United States:

Harvard (1636).
Yale (1701).
College of William and Mary (1692).
University of Pennsylvania (1749).
Columbia (1754).
Princeton (1746).
Brown University (1764).
Dartmouth (1769).
Rutgers (1770).
Hampden-Sidney (1776).
Washington and Lee (1782).
Washington University (1782).
Dickinson (1783).
St. Johns (1784).
Nashville (1785).
Georgetown (1789).
University of North Carolina (1789).

In Yale College we find the following courses offered for the session of 1702:

(1) Latin, five or six orations of Cicero; five or six books of Virgil; talking college Latin; (2) Greek, reading a portion of the New Testament; (3) Hebrew, Psalter; (4) Some instruction in mathematics and surveying; (5) Physics (Pierson); (6) Logic (Ramus).

In Dartmouth College, for the session of 1811, the following courses were offered:

Freshmen—Latin and Greek classics; arithmetic; English grammar; rhetoric.

Sophomore—Latin and Greek classics; logic; geography; arithmetic; geometry; trigonometry; algebra; conic sections; surveying; belles-lettres; criticism.

Junior—Latin and Greek classics; geometry; natural and moral philosophy; astronomy.

Senior—Metaphysics; theology; natural and political law.

The following courses were offered at Harvard for the session of 1825:

Freshmen—Livy, five books; plane geometry; Graeca Majora; Horace, algebra; English grammar.

Sophomore—Solid geometry; English history; Cicero; analytic geometry; rhetoric.

Junior—Logic; moral philosophy; chemistry; Tacitus; Homer; calculus; mechanics; electricity.

Senior—Intellectual philosophy; astronomy; Butler's analogy; political economy; chemistry; natural philosophy.

By comparing even the latest and most advanced of these courses of study, one will see that the best high schools of the present day are nearly the equivalent of the institutions from which Washington could have drawn his ideals, and that a university that now begins where the best colleges of his time left off, would surely be the equal of all that he could have hoped to see in his national university. Such institutions we now have in every state and in almost every city.

During the early years of our national existence it might have been possible to bring into one institution the greater part of the

young men desiring higher training by offering superior courses of study, but later, when college graduates began sending their sons, the *alma mater* was the first choice and was the college finally selected unless the opportunities were *far* greater at some other institution or else for economic reasons a near-by or home college was chosen. Now, when great efforts are put forth by the authorities of a university to keep pace with its foremost rival, this 'going away to college' is very great as may be seen in the accompanying table.

	Harvard.	University of Pennsylvania.	Yale.	University of Chicago.	Columbia.	Totals.
Chicago students at	74	3	82		8	167
Boston students at		3	5	2	5	15
New York students at	205	10	205	4		425
Connecticut students at	46	27		6	83	162
Philadelphia students at	47		27	4	5	83
Washington students at	33	7	25	2	9	76

The small number of Boston students who do not attend Harvard suggests the fact that there is in this city a preponderance of Harvard alumni, and the large number of students from New York at Harvard and Yale illustrates a similar condition, as does also the small number of Boston, New York, Connecticut and Philadelphia students at Chicago, though in this last instance distance doubtless exerts some influence.

It is evident that in the manifold centers of instruction with students from practically all the states, the process of 'freeing themselves from local prejudices and jealousies' is more effectual than if there were congregated at one place numbers so great that state associations would be formed for social reasons.

In Germany the migration of students is encouraged, and in this country the Association of American Universities is endeavoring to formulate a plan by which students may pass from one institution to another, receive credit for work wherever done and return for his degree to the university at which he matriculated.

In 1790 state capitals were as far apart in time as national capitals are to-day, and the prejudices and jealousies that now differentiate people of different nationalities are no greater than those that in Washington's time separated the citizens of the various states of the Union. And though the nations of the world will never be brought under a single government, the desirability of removing national prejudices is as great now as was a century ago the elimination of state jealousies. The logical conclusion therefore would be that the

'spirit of Washington,' moved forward a hundred years, would call for an international or world university.

Suppose Mr. Carnegie had responded to the invitation to found a national university and had given ten million dollars for that purpose, in what respect could it have been greater than the institutions now in existence?

The assets of a university are: (1) the endowment and educational plant *per se,* (2) the faculty, (3) the felicity of its situation.

The entire Carnegie bequest would be exhausted before Harvard or Columbia could be reached, and the University of Pennsylvania would be barely passed. It is thus apparent that even when supplemented by the opportunities for study which Washington affords, the advantages in a material way would not exceed existing institutions by an amount sufficient to overcome sentimental or other reasons that attract students elsewhere.

A superior faculty can be secured, in general, only by offering salaries in excess of those now paid, and if the new faculty is to be greater in point of numbers and superior in attainments to all other faculties, the income on the entire amount given would not suffice to meet this charge alone.

Again, such men could be found, in general, only in existing institutions, unless the risky experiment of taking untried persons should be followed, and the withdrawal of each superior man from a university would weaken it or the institution that was called upon to fill the vacancy thus created.

Washington unquestionably possesses material educational advantages, but the institutions already located there are living up to them at least in as complete a degree as could be reached by a new institution, unless it should become merely a competitor. To be more than a rival, it would require an endowment sufficiently great to procure an equipment and faculty surpassing those now in existence.

The advocates of a national university declare that it should not be a rival to existing institutions, and Mr. Carnegie asserts that the aim of his institution is 'To increase the efficiency of the universities and other institutions of learning throughout the country, by utilizing and adding to their existing facilities, and by aiding teachers in the various institutions for experimental and other work, in these institutions as far as may be advisable.' The purpose of one is to destroy existing institutions—the intention of the other is to build them up.

Assuming that the plan of operation of the Carnegie Institution to be along the lines announced in the daily press, it is easy to see that the work of no institution will be duplicated but supplemented, that students will be sent to the universities rather than drawn from them,

and that the ablest professors will be left under conditions where they can do the greatest good to the greatest number.

If a great specialist were called from his present position to Washington to conduct work more advanced than he now performs, the number of persons annually benefited by his instruction would be lessened. Suppose he should remain where he is, and these advanced workers be sent to him, he would be able to carry on the greater part, if not all, of his regular work and direct these special investigators as well. No institution would be crippled by the loss of its strongest men, but on the contrary it would be strengthened by the coming of exceptional students.

The Carnegie Institution might also reach a class that could not be benefited by a national university intended for graduate students only, for it could assist and encourage the exceptional man even if, through force of circumstances, he had been unable to obtain a degree. This surely is in the spirit of the man who became the commander in chief of an army without having passed through a military academy.

The fear that the humanities will be neglected in this institution is not well founded. For, though emphasis has been laid upon the opportunities Washington affords for scientific investigation, there is no implication that the sciences alone will receive attention. The advanced student in linguistics or philosophy needs direction and access to libraries and museums, and since it is impossible to bring into one place the ablest directors and the richest collections of books and original material, the very best that can be done is to send the investigator to the expert for direction and leave him free to pass from one city to another while searching the sources from which his knowledge must be drawn. Such workers are beyond the need of recitation drill and daily contact with an instructor, and it is very sure that while one guide might suffice, there would be no one locality where his work could be carried on to the best advantage.

It is likely that the Carnegie Institution will concern itself first of all in obtaining authentic and complete information regarding the great specialists of the world, the extent and scope of all libraries, museums, workshops, laboratories and special facilities for advanced work of every sort and character. It has secured groups of advisers in the various branches of art, science and philosophy, and thus doubly equipped, is able to direct intelligently the student where to go and how to proceed in order to complete the task which he had undertaken. If, in addition to this advice, the institution should find it possible to give financial aid to the worthy investigator the fondest hope of Washington will be more than reached and a grander spirit than his will become a thing of life.

BIOGRAPHY IN THE SCHOOLS.

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THE study described in the following pages was suggested by Professor E. Ray Lankester's tribute to Huxley which concludes, 'Ever since I was a little boy he (Huxley) has been my ideal and hero.'* An instance of a scientist in the rôle of 'ideal and hero' to the boyish imagination is rare enough to attract attention. How rare it is, and how low a rank the scientist takes in the scale of heroes, because of our faulty methods of education, will be indicated roughly by the figures which follow.

The study was planned originally to find out in a general way the relative degree of familiarity which a given number of students (high school and university) have with the names of military leaders, on the one hand, and the names of great scientists, on the other. Or rather, the aim was to get a quantitative statement of the degree to which familiarity with the names of the world's great military leaders surpasses familiarity with the names of its great scientists. For it is an every-day observation that the names of the former are on everybody's lips and that those of the latter class of men are not widely known.

When the tests reported here were actually given, the original plan, which included only the two classes just named, was extended so as to include eight other categories giving ten in all, as follows:

1. English and American poets.
2. Statesmen.
3. Inventors.
4. Scientists.
5. Orators.
6. Military leaders.
7. Occupations and industries fundamental to modern life.
8. Novelists.
9. Artists, including painters, sculptors and musicians.
10. Greek and Roman writers.

It will be noticed that with the exception of the first and last groups there is no limitation as to time or place.

The method followed was to ask the students to begin at a given signal, *e. g.*, the tap of a pencil, and write in three minutes the names of all the English and American poets they could recall. At the end of the first three minutes the second group, statesmen, was given, and so on to the end of the list. In all, six hundred and fifty high school and university students were tested on the ten classes named above.

Table I. gives the number of students belonging to each high school and university class tested, and the average number of each of the ten

* L. Huxley, 'Life and Letters of Thomas Huxley,' II., p. 447.

groups named by each class. For example, 216 pupils in the first year of high school were tested. The average number of poets named by the 216 pupils was 5.5; statesmen, 4.1, etc.

Tables II. and III. give the same items for boys and girls separately. It will be noticed that the university students tested belonged, in the main, to the third and fourth years.

TABLE I.

AVERAGE NUMBER NAMED BY BOTH BOYS AND GIRLS.

	High School.				University.			
Year.	1	2	3	4	1	2	3	4
Number of Students	216	148	94	54		26	88	24
1. English and American poets.	5.5	7.0	7.2	7.4			13.2	14.8
2. Statesmen	4.1	4.7	5.5	5.7			11.0	12.5
3. Inventors	3.4	3.6	3.8	3.4			5.9	7.3
4. Scientists	0.15	0.32	0.66	0.66			4.1	5.9
5. Orators	1.9	2.6	3.4	3.5			6.8	7.1
6. Military leaders	5.7	6.5	7.0	6.0			10.6	11.2
7. Occupations	4.7	4.7	6.7	7.5			8.9	9.7
8. Novelists	1.7	2.0	3.0	3.5			7.2	8.1
9. Artists	1.5	2.5	3.3	2.7			6.9	8.1
10. Greek and Roman writers	1.2	2.7	3.5	3.0			10.2	9.4

TABLE II.

AVERAGE NUMBER NAMED BY BOYS.

	High School.				University.			
Year.	1	2	3	4	1	2	3	4
Number of Boys.	102	70	46	28		26	41	14
1. English and American poets.	5.2	7.1	6.6	7.2		12.6	13.7	14.2
2, Statesmen	4.5	6.0	5.7	5.8		12.1	13.0	13.6
3. Inventors	3.7	4.1	4.8	4.2		6.9	7.9	8.6
4. Scientists	0.5	0.3	0.8	1.0		5.3	5.4	6.5
5. Orators	2.3	3.2	3.7	4.0		8.5	9.1	8.1
6. Military leaders	6.7	7.5	7.7	6.1		11.6	13.1	12.3
7. Occupations	5.3	5.4	7.2	8.0		9.5	10.0	9.9
8. Novelists	1.4	2.0	2.7	2.9		6.0	7.6	7.8
9. Artists	0.9	2.5	2.5	2.1		5.1	6.5	6.5
10. Greek and Roman writers	1.1	3.4	3.3	2.9		7.3	10.5	9.7

TABLE III.

AVERAGE NUMBER NAMED BY GIRLS.

	High School.				University.			
Year.	1	2	3	4	1	2	3	4
Number of Girls.	114	78	48	26			47	10
1. English and American poets.	5.8	7.0	7.8	7.6			12.8	15.7
2. Statesmen	3.7	3.5	5.4	5.6			9.2	10.7
3. Inventors	3.3	3.1	2.8	2.6			4.1	5.4
4. Scientists	0.2	0.3	0.5	0.2			3.0	4.5
5. Orators	1.6	2.1	3.1	2.9			4.9	5.5
6. Military leaders	4.8	5.7	6.3	5.6			8.5	9.4
7. Occupations	4.1	4.1	6.1	7.3			8.0	9.5
8. Novelists	1.9	2.0	3.2	4.1			6.9	8.7
9. Artists	2.0	2.5	4.1	3.4			7.2	10.5
10. Greek and Roman writers	1.2	2.1	3.6	3.2			9.9	9.0

It is not the intention to attempt an exhaustive treatment of the foregoing tables. They tell their own story, and the reader will draw his own conclusions on points which may happen to interest him. A few conclusions, however, of pedagogical and popular interest will be stated briefly.

Passing at once to a consideration of the tables there appears, as one naturally would expect, an increasing familiarity with the names in all the groups as we go from the first year in the high school to the senior year in the university. The largest percentages of gain are shown in the increased familiarity with the names of scientists, ancient classical writers and artists. The smallest gain is shown in the cases of military leaders and inventors. That is, the boy or girl in passing from the first year in the high school to the last year in the university will learn relatively vastly more names of scientists, ancient classical writers, and artists than he will of military men and inventors. As a university senior he will know forty times as many scientists' names as he knew as a first-year high school pupil; he will know eight times as many artists' names, and twice as many military names.

TABLE IV.

Rank.	High School.	Av. Number for all Grades.	Rank.	University.	Av. Number for all Classes.
1	Poets	6.5	1	Poets	13.5
2	Military leaders	6.2	2	Statesmen	11.3
3	Occupations	5.3	3	Military leaders	10.7
4	Statesmen	4.7	4	Greek and Roman writers.	10.0
5	Inventors	3.6	5	Occupations	9.0
6	Orators	2.6	6	Novelists	7.3
7	Greek and Roman writers.	2.29	7	Artists	7.0
8	Novelists	2.28	8	Orators	6.8
9	Artists	2.27	9	Inventors	6.2
10	Scientists	0.35	10	Scientists	4.4

If one examines Table IV. one finds that in the high school in order of familiarity, the names of English and American poets rank first, with military leaders as a close second. Statesmen stand third, inventors fourth, orators fifth, Greek and Roman writers sixth, novelists seventh, artists eighth, scientists tenth. It should be observed that the ranks of novelists, artists and Greek and Roman writers are nearly the same.

When we pass to the junior and senior years of the university, we find this order considerably changed. Poets rank first, statesmen second, military leaders third, Greek and Roman writers fourth, occupations fifth, novelists sixth, artists seventh, orators eighth, inventors ninth and scientists tenth.

If the two sets of figures are compared, it is found that the university students are relatively—as well as absolutely—more familiar than the high school pupils with the names of statesmen, novelists, artists and ancient classical writers. They are relatively, though not absolutely, less familiar with the names of inventors, orators and military leaders.

It appears further that the three highest groups, omitting occupations, for both high school and university students are poets, statesmen and military men, and that scientists are least known by both classes of students. This is explained partly by the fact that students hear more about men in the first named classes and partly by the further fact that the careers of statesmen, orators and military leaders appeal strongly to the imagination of the young. The great deeds of men belonging to these groups are concrete, and have form, color and tone, easily grasped by young minds. The achievements of the man of science have few of these characteristics, and so people generally, young and old alike, think of the scientist much as Heine said, in substance, of Kant, 'He was a philosopher, and so has no biography.'

The figures probably will have no surprises for those who have thought about the matter. But it is of interest to dwell briefly on their bearing upon certain questions which are of perennial interest to educators, and to students of the broader aspects of social tendencies. Any one who has been through our public schools will remember a number of studies which are rich in biographical material, hero worship, and suggestions as to personal ideals, while others are entirely devoid of them. It is hoped that this study will throw some light upon the questions of what kinds of personal ideals are fostered by the school, and what kinds of school work receive most emphasis.

To the writers the results indicate pretty clearly where modern education, in this country at least, lays greatest stress, on what things it drills, wherein are the main lines of interest and study, and, possibly, what sort of ideals are held up to school children. The far-reaching social and ethical significance of these influences needs only to be suggested in this connection. Boys and girls dream of becoming like persons whose lives and achievements they are led to admire. The boy reads of the military man's victories and longs to follow in his footsteps. He hears of the statesman's laurels won in legislative halls, or on the stump, and so pictures himself likewise the admired of all admirers. It is not an exaggeration to say that nine of every ten of the boys who graduate from our high schools count it a greater thing to be a member of the state legislature, or to be captain of the local militia, than to be a Pasteur, Virchow, Huxley, Wagner or Phidias.

Of course the ability to run off a long list of names of scientists, or of artists is not necessarily accompanied by a knowledge of science, on the one hand, or by a knowledge of art, on the other. But it is evidence, even though slight, of interest in the achievements of the scientists and artists and probably some degree of respect, even admiration, for the great names in those two fields. On the other hand, it is safe to say that pupils will not become zealous in the study of either science or art without, at the same time, becoming deeply interested in the heroes in those subjects. It is likely, for example, that a person who knows something of music and is interested in it will be familiar with a number of names of the world's great musicians. And it is also highly probable that if one does not know these great names in music one has little knowledge of, or interest in, that art. In a word, the presumption is strong that if a pupil is interested in a given field of activity he will also know the great names in that field. It is also true that one of the surest and quickest ways to get pupils intertested in a given line of study is to arouse their interest in the lives of persons distinguished in that line. President Stanley Hall puts the matter admirably in his article on 'Criticisms of High School Physics.'* What Dr. Hall says with reference to physics, holds true of the other sciences. "Boys in their teens," he writes, "have a veritable passion for the stories of great men, and the heroology of physics, which, if rightly applied, might generate a momentum of interest that would even take them through the course as laid out, should find a place. . . . Physics has its saints and martyrs and devotees, its dramatic incidents and epochs, its struggles with superstition, its glorious triumphs, and a judicious seasoning perhaps of the whole course with a few references and reports by choice with material from this field would, I think, do much." The practical point in mind is—teachers of science should do more in the way of acquainting pupils with the lives of scientists, first from a sense of justice to the memory of those who have wrought so vastly for the good of mankind, and for the further purpose of inspiring young persons to take up science as a life work.

The bearing of our figures upon the fact of the general neglect of art in the public schools of America is worth noticing briefly. President Butler of Columbia University defines education as a gradual adjustment to the spiritual possessions or inheritances of the race, these inheritances being literary, scientific, esthetic, institutional and religious. With reference to the importance of the esthetic inheritance and its place in a well-rounded education he says, "We should no longer think of applying the word cultivated to a man or woman who had no esthetic sense, no feeling for the beautiful, no appreciation of the sub-

* *Pedagogical Seminary*, IX., p. 194.

lime, because we should be justified in saying, on psychological grounds, that that nature was deficient and defective. This great aspect of civilization . . . is a necessary factor in adjusting ourselves to the full richness of human conquest and human acquisition . . . we should see to it that the esthetic inheritance is placed side by side with the scientific and the literary in the education of the human child."* Among the humanizing elements of education as it should be organized esthetic insight and appreciation rank high. Yet our figures bear testimony to what every one knows without tables of statistics, that art is neglected in the education of the American youth so far as the schools are concerned. The fact that high school seniors who can name on an average 5.7 statesmen know only 2.7 painters, sculptors and musicians in all the world's history is too significant to require comment. Is it a fair showing? Does it not indicate an over emphasis of certain lines of school work to the neglect of others, and to the permanent injury of pupils? Does it not indicate an overdoing of the literary side? Are we not too much enslaved to letters and books even in our humanizing? One may even ask, has the poet any just claim to so much more of the pupil's time and interest, as indicated by the figures, than the artist who bodies forth his ideals on canvas or in stone?

Finally a word regarding a by-product of the investigation. An examination of the individual papers brings home to one anew that much even of the university student's knowledge is a vague, jumbled patch-work of shadows and blurs. A few instances from a vast number will illustrate the point. We are told that Victor Hugo was a military leader; that Aristotle and Virgil were great orators; that Isosceles was a great orator; that Emerson and Bryant and Lowell were English poets, and Bismarck an English statesman; that Romeo was a Roman writer; that Shakespeare was a Latin author and wrote Julius Cæsar; that Macaulay was a Roman writer and wrote Lays of Ancient Rome. Confusion and haziness are the banes of the university student as they are of all grades of learners. We are in constant danger of over estimating the number of clear-cut live facts or principles in the possession of any pupil or student. The question naturally arises, is it not possible that modern education with its wealth of material which it pours forth on students with such lavish hands does not smother and confuse rather than enliven and illumine?

* Butler, 'The Meaning of Education,' Ch. I.

A VISIT TO THE QUARRY-CAVES OF JERUSALEM.

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THE hill-country of Judea consists chiefly of one great anticlinal fold of a thick series of Upper Cretaceous strata, mostly limestones, the axis of the fold having a nearly due north and south trend. This series rises from beneath the slightly elevated and comparatively narrow Tertiary plain which borders the Mediterranean Sea, is broken by erosion into rugged hills and deep ravines, reaches, even in its present condition of great denudation, an elevation of about 2,500 feet, and then dips eastward. The angle of dip being greater upon the eastern than upon the western side of the axis, the whole series of strata is carried beneath the surface of the Dead Sea, which is only ten or twelve miles east of the axis in a straight line and more than 1,200 feet below ocean level. East of the western shore of the Dead Sea the geological structure is complicated by faults, but that matter need not be discussed. Jerusalem is situated upon the east side of, but very near to, the axis, and because of the presence of the great depression in the land surface called the 'Ghor' one gets good views from the hilltops that rise around the city upon and near the axis. Within range of distinct vision are the Wilderness of Judea, the Hills of Edom, and especially the Mountains of Moab with the Dead Sea and the lower end of the Jordan valley lying near their base. The great series of strata thus folded, consisting, as it does, largely of compact limestone, has furnished only a scanty, although fertile, soil by the natural process of disintegration, and that memorable land is, therefore, preeminently a region of stony ground.

The lithological character of those strata is favorable for the production of natural caves, and many such exist there as is well known from references to them in both sacred and profane history. All the drainage lines of the region, however, being short and most of them declivitous, none of those caves is of large size compared with the great caverns of other regions. Many of those small Judean caves have been artificially enlarged and adapted to use as store-houses, stables, tombs and even as human dwellings. Numerous rock excavations which are wholly artificial have also been made from time immemorial and for various purposes, but I shall refer only to those which have resulted from the quarrying of stone for building purposes, and

especially mention only those which now exist at Jerusalem, and which are among the most important of their kind.

Much of the limestone of the Judean fold is suitable for common masonry and it is everywhere so used, but one stratum which comes to the surface at Jerusalem is especially valuable. Its superior quality seems to be limited to the vicinity of that ancient city, for that quality has not been found in the equivalent stratum of the series elsewhere. It is a light gray limestone sometimes, and, not improperly, called marble, but locally it is known as Malaké or the Royal stone. It is of good appearance, great durability and of uniform texture, and is worked with comparative ease. The place of surface outcrop of this stratum within the city walls is now covered with compactly built houses, but all the good stone was doubtless removed from there long before the present city and its walls were built and its place filled with the accumulated débris of centuries. The first surface quarries of this fine stone must have been very ancient, and the condition of the ground surface just north of the present north wall of the city shows that they were extensive. But even in ancient times, the exposures at the surface of this valuable stone were inadequate to the demand, and the quarries were extended underground, following the dip of the strata, which is there about ten degrees. In this way the quarry caves were formed, the firm stratum above the Malaké making a good roof and the equally firm one beneath making a good floor. The so-called Grotto of Jeremiah, just north of the present north wall of the city, is one of those quarry caves. It is accessible to travelers for an entrance fee and attracts considerable attention because tradition says the 'Lamentations' were written there. But the most extensive cave of this kind exists beneath the Mohammedan quarter, or northeastern part of the city itself, and is not accessible except by official permission. From its location and historical references to it, I have no doubt that it was this cave which furnished at least the greater part of the fine stone for Solomon's temple and other great buildings of ancient Jerusalem. I do not know by what distinctive name it may have been called in ancient times, but it is now locally called by a name that signifies 'The Cotton Grotto.'

Through our American consul, a small party of us got permission from the Turkish governor of Jerusalem to visit this cave, and he detailed a very courteous officer to accompany us. We passed out of the city by the north, or Damascus gate, turned eastward and went about one hundred yards along the trail which encircles the city near the walls and came to a place opposite the 'Grotto of Jeremiah,' where a rock escarpment or low cliff forms the base of the city wall. The entrance to the cave is in the face of this escarpment, and it is so

inconspicuous that I did not specially notice it when passing the place on former occasions. Though not originally large, the entrance has been narrowed by rude masonry and a wooden door placed therein. Our officer-guide opened the door by means of an ordinary key which he brought with him, an attendant furnished each of us with a lighted taper, and we began our march into the darkness.

The artificial character of the cave was at once apparent from the presence of numerous rude piers of the original stone which were left by the quarrymen to support the roof and that part of the city which rests upon it. The floor has the general eastward dip of the strata and, although not very even, it was nowhere difficult to traverse. The height of the roof above the floor differs considerably at different places, probably because of the varying thickness of the fine part of the Royal stratum. In some places it is hardly more than ten feet, but in others I estimated the height at twenty feet or more. We walked through the long rude corridors, mostly in a southerly and south-easterly direction, reaching a distance from the entrance that I estimated to be not less than a quarter of a mile. I made no estimate of the cubic contents of the cave, but its great size gave me a distinct impression that it is large enough to have furnished all the fine stone that was required for the grand buildings of the ancient city and of its successive rehabilitations.

As we progressed southward from the entrance the west limiting wall came occasionally into view. It appeared to be quite uneven and I detected there no conditions of the rock which I thought attributable to systematic quarrying such as those which I soon afterward observed in other parts of the cave. For that, and the other reasons already mentioned, I think all the Malaké stone which originally existed on the west side and extended to the surface in reverse direction of the dip, was long ago removed and its place supplied with rejected and inferior stone. When we reached the south and east limiting walls of the cave, we found them perpendicular and bearing abundant marks made by the quarrymen. The character of the great excavation and the peculiar quarry-marks which we found upon its walls left no room for doubt as to its great antiquity nor of the fact that it was wholly the work of human hands. What we saw also agreed with numerous well-known legends and with trustworthy historical references to quarry caves of this kind. The surfaces, which bear the marks referred to having never been exposed to the weather nor to extremes of heat and cold, have remained unchanged, and even those marks which were made by the cutting tools of the workmen are still plainly visible. Fragments of their burnt-clay lamps and water bottles are also occasionally found in the scanty débris, which was produced by their peculiar

methods of quarrying. Dr. Cyrus Adler, of the Smithsonian Institution, upon the occasion of his visit there, was so fortunate as to discover a perfect lamp and a damaged water bottle, which he has deposited in the U. S. National Museum. The little niches cut out of the face of the rock to receive the lamps are still there, and far within the cave there is a small spring, the clear water of which now fills the little basin which was cut in the rocky floor centuries ago to receive it. Although it is not probable that any stone has been quarried in this cave since a period at least as remote as the beginning of the Christian era, so little has time affected the wrought surfaces of the rock since the last quarrying was done there, one might almost expect to see the old masons return to their work at any time, to hear at high noon the call from labor to refreshment and, in the dim light of their tiny lamps, to see them gather around the spring for their mid-day meal. Perhaps it was just here that, according to the legend, the grand master was murdered when he came to inspect the quarry work. The thought startled me, and I looked around half expecting to see hostile faces peering at us out of the darkness.

The principal method of quarrying that was practised in this cave was laborious but effective, and the same method is known to have been practised in other ancient quarries. It is a hand method, the effect of which is much like that of one now employed by aid of machinery in quarrying marble and massive limestones. A perpendicular face of the rock was prepared and the outlines of the desired ashlars drawn upon it. The principal tool used for the shaping and removal of such stones was a long slender chisel, a little more than an inch wide, which was struck on end with a hammer or mallet. A narrow groove or slot was thus cut on all the drawn lines and of sufficient depth for the full thickness of the ashlar. The latter was then removed by driving wooden wedges into the slots, the impact of which split the ashlar off at its back face and allowed it to fall upon the quarry floor. The split face was usually nearly even, because of the uniform texture of the stone, but any defect in that part of it would cause it to split unevenly. We saw one large ashlar lying where it had fallen, 'rejected of the builders,' because its back face had broken off obliquely.

In most places the quarrying of the Royal stratum appears to have been prosecuted as far as was intended, and the stones were all removed, but in one place, at least, the work was for same reason left unfinished. Some of the ashlars were only outlined and some partially cut out, the great stones still remaining in their original places. Perhaps the work was interrupted by a strike of the quarrymen and never resumed because of failure to obtain compliance with their demands. But workmen had few rights in those days, and that suspension of quarry work

was more probably due to some deed of violence for, unfortunately, we now know that this cave has repeatedly been the scene of horrors that make the heart sick to contemplate. This method of cutting out ashlars was economical of material and it produced very little débris in the quarry. The stones were also cut so nearly of the desired shape that they required little dressing before taking their places in the building. This method of quarrying also agrees with the scriptural account of the precision with which the stones of Solomon's temple were prepared in the quarry.

Although we have now so much evidence of the true nature and great antiquity of this cave, from and after the destruction of Jerusalem by Titus it remained unknown for centuries. Its entrance became so covered with the débris which accumulated in the destruction and rebuilding of the city that all knowledge of its position, and even of its existence, became lost until the year 1852, when its only now known entrance was discovered by Dr. J. T. Barclay, an American missionary. Dr. Barclay gives a brief account of his discovery and exploration in his book, 'The City of the Great King,' wherein he estimates the length of the cave at rather more than a quarter of a mile, and its greatest breadth at less than half that distance. His estimate of its length agrees with my own, but Dr. Adler, in the *Jewish Quarterly Review,* for April, 1896, estimates it at about 1,000 feet. Its position is approximately indicated upon some lately published maps by an outline which shows a length of only about 500 feet, but this representation is too far from the truth to deserve consideration. The distance from the entrance of the cave in the north wall of the city to the south wall of the same is barely 3,000 feet, and by my estimate of the length of the cave it extends considerably more than one third the distance across the city. I am, therefore, of the opinion that it extends beneath the northwest corner of the temple area and consequently beneath the governor's residence, which is closely adjacent.

Sir J. W. Dawson, in his book 'Egypt and Syria' suggests that there was formerly a ramp or sloping tramway, leading from the quarry into the temple area by which stones were taken up to the building site of the temple. Nothing of that kind, however, has ever been discovered and the suggestion does not agree with the statements made by Professor H. Graetz in his 'History of the Jews.' Professor Graetz states that the stones used in the building of the temple were obtained from underground quarries by men who were compelled to labor there. He says that "Eighty thousand of these unhappy beings worked in the stone quarries day and night by the light of lamps. They were under the direction of a man from Biblos (Giblem), who understood the art of hewing heavy blocks from rocks and of giving them the necessary

shape for dove-tailing. Twenty thousand slaves removed the heavy blocks from the mouth of the quarry and carried them to the building site."

Hard as was the lot of the workmen in the quarry-caves in times of so-called peace, it was not comparable in horror with that of the beseiged inhabitant who resorted to those underground retreats in time of war. The following paragraph from Josephus's account of what took place in the quarry-caves of Jerusalem at the time of its seige and destruction by Titus is frightfully descriptive of those terrible scenes. "The Romans slew some of them, some they carried captives and others they made search for underground, and when they found where they were they broke up the ground and slew all they met with. There were also found slain there above two thousand persons, partly by their own hands and party by one another, but chiefly destroyed by the famine; but then the ill savor of their bodies was most offensive to those who lighted upon them, insomuch that some were obliged to get away immediately, while others were so greedy of gain that they would go in among the dead bodies that lay on heaps and tread upon them, for a great deal of treasure was found in these caverns and the hope of gain made every way of getting it to be esteemed lawful."

As the centuries have passed away decay has so completely done its work there upon all organic matter that not even a bone of all that multitude of the dead has been found with the floor-dust of the cave. Even the air is not now oppressive, although there is apparently no other aperture or entrance than the one by which we entered. I also saw no appearance of fouling of the cave by seepage from the city water-pools nor from the surface drainage of the unsanitary streets and alleys overhead. As we turned to retrace our steps all was so peaceful and untainted it was difficult to realize that man's inhumanity to man was ever so terribly demonstrated there as credible historians have compelled us to believe.

Because of the great difference between the methods of modern and ancient warfare, the scenes which accompanied the various sieges and captures which Jerusalem has suffered can never be repeated; but if a hostile army should ever again camp before the city with intent to destroy it, an effort would doubtless be made to place a few tons of dynamite at the farther end of that anciently constructed mine. In the twinkling of an eye a more complete destruction would follow than that which was inflicted by Titus in his six months of siege and spoliation. Indeed, considering the present possibility of smuggling high explosives into that mine, and the wide prevalence of wanton anarchism, it would be prudent to guard it with special care.

THE NILE DAMS AND RESERVOIR.*

By SIR BENJAMIN BAKER, F.R.S.,
PAST PRESIDENT INSTITUTION OF CIVIL ENGINEERS.

THE Nile Reservoir at Aswân will contain over 1,000 million tons of water. This statement will probably convey little meaning to most people; and in truth the quantity may be made to appear either small or large at will by a judicious selection of illustrations. Thus the absolute insignificance to Egypt of 1,000 million tons of water in a reservoir, as compared with a reasonable rainfall, will be apparent at once when it is considered that the annual rainfall on the area included within the four-mile cab radius from Charing Cross is about 100 million tons, and that the rainfall on London and its suburbs within a thirteen-mile radius would, therefore, about suffice to fill the Nile Reservoir. On the other hand, we may, by choosing other illustrations, restore the Nile Reservoir to the dignity of its just position of one of the greatest engineering works of the day. Thus the question of the water supply of London, and its prospective population of 11¼ millions, has been prominently before the public for some years; and many will remember what was termed the colossal project of our member, Sir Alexander Binnie, late Engineeer of the London County Council, for constructing reservoirs in every reasonably available valley in Wales, to store up water for London, and to supply compensation water to the Welsh rivers affected thereby. Well, the united contents of the whole of those reservoirs would be less than half that of the great Nile Reservoir. Again, the Nile Reservoir would hold more than enough water for one year's full domestic supply to every city, town and village in the United Kingdom with its 42 million inhabitants. But possibly the best way of giving an idea of the magnitude of the work, and its utility to cultivation in a thirsty land, is by considering the volume of the water issuing from the reservoir during the three or four summer months, when scarcity of supply prevails in the river and the needs of the cultivators are greatest. At that time the flow from the reservoir will be equivalent to a river double the size of the Thames in mean annual flood condition. It will be recognized at once that a good many buckets would have to be set at work to bale out a river like that, and yet the scarcity of water in the Nile itself, and in the canals, during the months of April, May and June, is such that even dipping the water out of the channels in buckets has to be con-

* Address given before the Royal Institution of Great Britain.

trolled by strict regulations. Thus, two years ago, when the Nile was below the average in summer discharge, it was decreed in Upper Egypt that the 'lifting machines,' which include the shadoof, or bucket-and-pole system, and the sakieh, or oxen-driven chain of buckets, should be worked not more than from five to eleven consecutive days, and stop the following nine to thirteen days, between the middle of April and the middle of July; and the order in which the different districts were to receive a supply was carefully specified, so that, as far as possible, every crop should get watered once in about three weeks. When it is remembered that a single watering of an acre of land means, where shadoofs are concerned, raising by manual power about 400 tons of water to varying heights up to 25 feet, and that four or five waterings

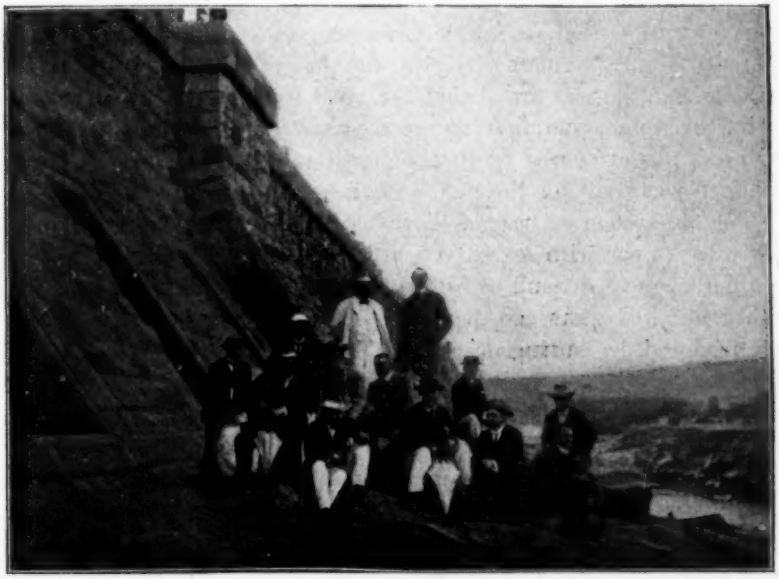


FIG. 1. THE DAM AT ASWÂN, VISITED BY THE LATE CECIL RHODES AND HIS PARTY.

are required to raise a summer crop, it will be seen what a vast amount of human labor is saved throughout the world by the providential circumstance that in ordinary cases water tumbles down from the clouds, and has not, as in Egypt, to be dragged up from channels and wells. Shadoof work, under average conditions, involves one man's labor for at least one hundred days for each acre of summer crop; so that even at 6d. per day for labor, the extra cost of cultivation due to the absence of rain would amount to 50s. per acre.

The great Nile Reservoir and Dam at Aswân, the Barrage at Asyût, and various supplementary works in the way of distributing canals and regulators, are designed with the object of mitigating the evils

enumerated above, by supplying in summer a larger volume of water at a higher level in the canals, so that not only can more land be irrigated, but that labor in lifting water will be saved. When the International Commission, eight years ago, recommended the construction of a large reservoir somewhere in the Nile valley, I was desirous of knowing what would be the opinion of a real old-fashioned native landowner on the subject; and was introduced to one whose qualifications were considered to be of no mean order, as he was a descendant of the Prophet, very rich, and had been twice warned by the government that he would probably be hanged if any more bodies of servants he had quarrelled with were found floating in the Nile. He was a very stout old man, and, between paroxysms of bronchial coughing, he assured me that there could be nothing in the project of a Nile reservoir, or it would have been done at least 4,000 years ago. In contrast with this I may mention that, a few months ago, the most modern and enlightened of all the rulers of Egypt, the present Khedive, when visiting the dam, said he was proud that the great work was being carried out during his reign, and that the good services rendered by his British engineers was evidenced by the London County Council coming to his Public Works Staff for their chief engineer.

The old system of irrigation, which the descendant of the Prophet looked back upon with regret, was little more than a high Nile flooding of different areas of land or basins surrounded by embankments. Less than a hundred years ago, perennial irrigation was first attempted to be introduced, by cutting deep canals to convey the water to the lands when the Nile was at its low summer level. When the Nile rose, these canals had to be blocked by temporary earthen dams, or the current would have wrought destruction. As a result, they silted up, and had to be cleared of many millions of tons of mud each year by enforced labor, much misery and extortion resulting therefrom. About half a century ago, the first serious attempt to improve matters was made by the construction of the celebrated barrage at the apex of the Delta. This work consists, in effect, of two brick arched viaducts crossing the Rosetta and Damietta branches of the Nile, having together 132 arches of 16 feet 4 inches span, which were entirely closed by iron sluices during the summer months, thus heading up the water some 15 feet, and throwing it at a high level into the main irrigation canals below Cairo. The latter are six in number, the largest being the central canal at the apex of the Delta, which, even in the exceptionally dry time of June, 1900, was carrying a volume of water one-fourth greater than the Thames in mean flood, whilst the two canals right and left of the two branches of the river carried together one half more than the Thames, and the Ismailieh Canal, running down to the Suez Canal, though starved in supply, was still a river twice the size of the Thames at the same time of the year. At flood times the discharges of all the canals

are, of course, enormously increased. It will be recognized at once, therefore, that, as in the summer months the whole flow of the Nile is arrested and thrown into the aforesaid canals, the old barrage will always remain the most important work connected with the irrigation of Egypt. It was constructed under great difficulties by French engineers, subject to the passing whims of their Oriental chiefs. About fifteen years elapsed between the commencement of the work and the closing of all the sluices, and another twenty years before the structure was sufficiently strengthened by British engineers to fulfil the duties for which it was originally designed. All the difficulties arose from the nature of the foundations, as the timber sheet piling wholly failed to prevent the substructure from being undermined by the head of water carrying away the fine sand and silt upon which the barrage was built. At Asyût, cast-iron sheet piling was used, as will hereafter be described. It is impossible to say what the cost of the old barrage has been from first to last, but probably nearly ten times that of the recently-completed Asyût Barrage. Forced labor was largely employed in its construction, and at one time 12,000 soldiers, 3,000 marines, 2,000 laborers, and 1,000 masons were at work at the old barrage.

In connection with the Nile Reservoir, subsidiary weirs have been constructed below the old barrage to reduce the stress on that structure. The system adopted was a novel one, reflecting great credit on Major Brown, Inspector-General of Irrigation in Lower Egypt. His aim was to dispense almost entirely with plant and skilled labor; and so, without attempting to dry the bed of the river, he made solid masonry blocks under water, by grouting rubble dropped by natives into a movable timber caisson. Both branches of the Nile were thus dammed in three seasons, at a cost, including navigation locks, of about half a million sterling. Many other subsidiary works have been and will be constructed, including regulators, such as that on the Bahr Yusuf Canal.

Asyût Barrage.

By far the most important of the works constructed to enable the water stored up in the great reservoir to be utilized to the greatest advantage is the Barrage across the Nile at Asyût, about 250 miles above Cairo, which was commenced by Sir John Aird and Co. in the winter of 1898, and completed this spring. As already stated, in general principle this work resembles the old barrage at the apex of the Delta; but in details of construction there is no similarity, nor in material, as the old work is of brick and the new one of stone.

The total length of the structure is 2,750 feet, or rather more than half a mile, and it includes 111 arched openings of 16 feet 4 inches span, capable of being closed by steel sluice gates 16 feet in height. The object of the work is to improve the present perennial irrigation of lands in Middle Egypt and the Fayoum, and to bring an additional

area of about 300,000 acres under such irrigation, by throwing more water at a higher level into the great Ibrahimiyah Canal, whose intake is immediately above the Barrage (Fig. 2).

The piers and arches are founded upon a platform of masonry 87 feet wide and 10 feet thick, protected up and down by a continuous and impermeable line of cast-iron grooved and tongued sheet piling, with cemented joints. This piling extends into the sand bed of the river to a depth of 23 feet below the upper surface of the floor, and thus cuts off the water and prevents the undermining action which caused so much trouble and expense in the case of the old barrage. The height of the roadway above the floor is 41 feet, and the length of the piers up and down stream 51 feet. The river bed is protected against erosion for a width of 67 feet up stream by stone pitching, with clay

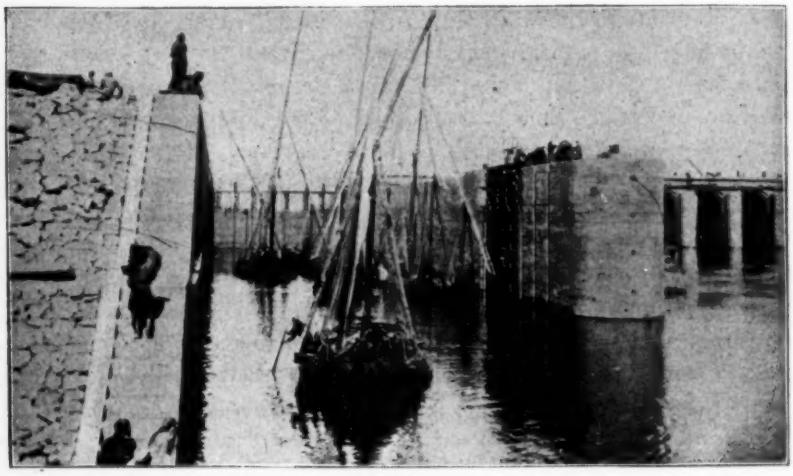


FIG. 2. ASYÛT LOCK.

puddle underneath to check infiltration, and down stream for a similar width by stone pitching, with an inverted filter-bed underneath, so that any springs which may arise from the head of water above the sluices shall not carry sand with them from underneath the pitching.

It is easy enough to construct dams and barrages on paper, but wherever water is concerned the real difficulty and interest is in the practical execution of the works, for water never sleeps, but day and night is stealthily seeking to defeat your plans. On the Nile the conditions are very special, and in some respects advantageous. There is only one flood in the year, and within small limits the time of its occurrence can be foretold, and arrangements made accordingly. It would have been impossible to have carried out the Nile works on the system adopted had the river been subject to frequent floods. The working season for below-water work on the Nile lies practically between Novem-

ber and July, for nothing would be gained by starting the temporary enclosing embankments, or sudds, when the river was at a higher level than it is in November; nor would it be possible at any reasonable cost to prevent the sudds from being swept away by the flood in July. At Asyût the mode of procedure was to enclose the site of the proposed season's work by temporary dams or sudds of sandbags and earthwork, then to pump out and keep the water down by powerful centrifugal pumps, crowd on the men, excavate, drive the cast-iron sheet piling, build the masonry platform and piers, lay the aprons of puddle and pitching, and get the work some height above low Nile level before the end of June, so that the temporary dams should not require reconstruction after being swept away by the flood. The busiest months were May and June, when in the year 1900 the average daily number of men was 13,000. It is also then the hottest; the shade temperature rising to 118 degrees. To keep the water down, seventeen 12-inch centrifugal pumps, throwing enough water for the supply of a city of two million inhabitants, had to be kept going, and in a single season as many as one and a half million sandbags were used in these temporary dams. The bed of the river being of extremely mobile sand, the constant working of the pumps occasionally drew away sand from under the adjoining completed portions of the foundations, necessitating the drilling of many holes through the 10-foot thick masonry platform, and grouting under pressure with liquid cement. About 1,000 springs also burst up through the sand, each one of which required special treatment. A new regulator had to be constructed for the Ibrahimiyah Canal, with nine arches and sluices, to control the high floods and prevent damage to the Canal and the works connected therewith.

Aswân.

Asyût, as already observed, is about 250 miles above Cairo. The great dam at Aswân is 600 miles above the same point. Between Asyût and Aswân the remains of many temples exist, of far greater interest and importance than those at Philæ. The latter ruins, however, have attracted more attention in recent days, because, being situated immediately above the Dam, the filling of the reservoir will partially flood Philæ Island during the tourist season.

It would be idle to speculate as to who first thought of constructing a reservoir in the Nile valley, or who first arrived at the conclusion that the site of the present dam above Aswân was the best one. Mr. Willcocks, one of the ablest engineers of the Public Works Department of Egypt, who was instructed by Sir William Garstin to survey various suggested sites for a dam between Cairo and Wady Halfa, unhesitatingly decided that the Aswân site was the best, and the majority of the International Committee, who visited the sites in 1894, came to the same conclusion. This conclusion had, however, been anticipated

by Sir Samuel Baker more than forty years ago, from mere inspection of the site without surveys. In suggesting a series of dams across the Nile to form reservoirs from Khartoum downwards, he wrote: "The great work might be commenced by a single dam above the first cataract at Aswân, at a spot where the river is walled in by granite hills. By raising the level of the Nile 60 feet, obstructions would be buried in the depths of the river, and sluice-gates and canals would conduct the shipping up and down stream." This single dam, proposed by Sir Samuel Baker forty years ago, is in effect the one which is now on the point of completion. Mr. Willcocks' original design consisted practically of a group of independent dams, curved on plan, and the arrangement of sluices and dimensions of the dam differed considerably from those of the executed work. There is no doubt that the single dam, 1¼ miles in length, constitutes a more imposing monumental work than a series of detached dams, and that it also offered greater facilities to a contractor for the organization of his work and rapid construction; and, further, the straight dam is better able to resist temperature stresses from extreme heat without cracking. Two dams across the Nile, the old barrage and the Asyût Barrage, have already been described; and it will be hardly necessary to say, therefore, that the Aswân Dam is not a solid wall, but is pierced with sluice openings of sufficient area for the flood discharge of the river, which may amount to 15,000 tons of water per second. There are 180 such openings, mostly 23 feet high by 6 feet 6 inches wide; and where subject to heavy pressure, when being moved, they are of the well-known Stoney roller pattern.

Although the preliminary studies of Mr. Willcocks and the other government engineers occupied some four years, there was neither time nor money to sink shafts in the bed of the river, to ascertain the real character of what was called in the engineer's report 'an extensive outcrop of syenite and quartz diorite clean across the valley of the Nile,' giving 'sound rock everywhere at a very convenient level.' Unfortunately, the rock proved to be unsound in many places to a considerable depth, with schistous micaceous masses of a very friable nature, which necessitated carrying down the foundations of the dam sometimes more than 40 feet deeper than was originally anticipated or provided for in the contract. As the thickness of the dam is nearly 100 feet at the base, this misapprehension as to the character of the rock involved a very large increase in the contract quantity and cost of the granite masonry of the dam. The total length of the dam is about 1¼ miles; the maximum height from foundation, about 130 feet; the difference of level of water above and below, 67 feet; and the total weight of masonry over one million tons. Navigation is provided for by a 'ladder' of four locks, each 260 feet long by 32 feet wide.

As remarked in the case of Asyût, the difficulties in dam construction are not in design, but in the carrying out of the works. It would not be too much to say that any practical man standing on the verge of one of the cataract channels, hearing and seeing the apparently irresistible torrents of foaming water thundering down, would regard the putting in of foundations to a depth of 40 feet below the bed of the cataract in the short season available each year as an appalling undertaking. When the rotten rock in the bed was first discovered, I told Lord Cromer frankly that I could not say what the extra cost or time involved by this and other unforeseen conditions would be, and that all I could say was that, however bad the conditions, the job could be done. He replied that he must be satisfied with this assurance, and

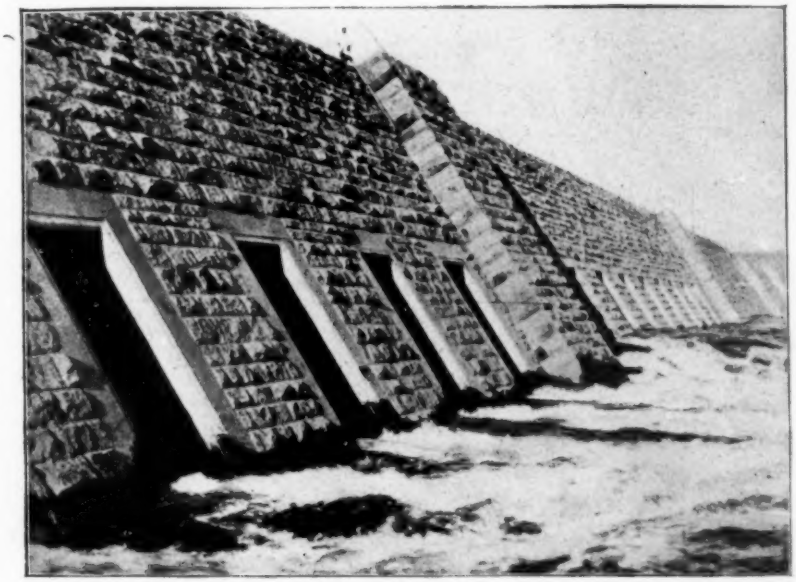


FIG. 3. NORTH SIDE OF DAM, LOOKING WEST.

say that the dam had to be completed whatever the time and cost. With a strong man at the head of affairs, both engineers and contractors—who often are suffering more anxiety than they care to show—are encouraged, and works, however difficult, have a habit of getting completed, and sometimes, as in the present case, in less than the original contract time.

The contract was let to Sir John Aird and Co., with Messrs. Ransomes and Rapier as subcontractors for the steelwork, in February, 1898, and they at once commenced to take possession of the site of the works, and of as much of the adjoining desert as they desired in order to construct railways, build dwellings, offices, machine shops, stores and hospitals, and provide sanitary arrangements, water supply, and

the multitudinous things incidental to the transformation of a remote desert tract into a busy manufacturing town. Two months after signing the contract the permanent works were commenced, and before the end of the year thousands of native laborers and hundreds of Italian granite masons were hard at work. On February 12, 1899, the foundation stone of the dam was laid by H.R.H. the Duke of Connaught. Many plans were considered by the engineers and contractors for putting in the foundations of the dam across the roaring cataract channels, and it was finally decided to form temporary rubble dams across three of the channels below the site of the great dam, so as to break the force of the torrent and get a pond of comparatively still water up stream to work in. Stones of from one ton to twelve tons in

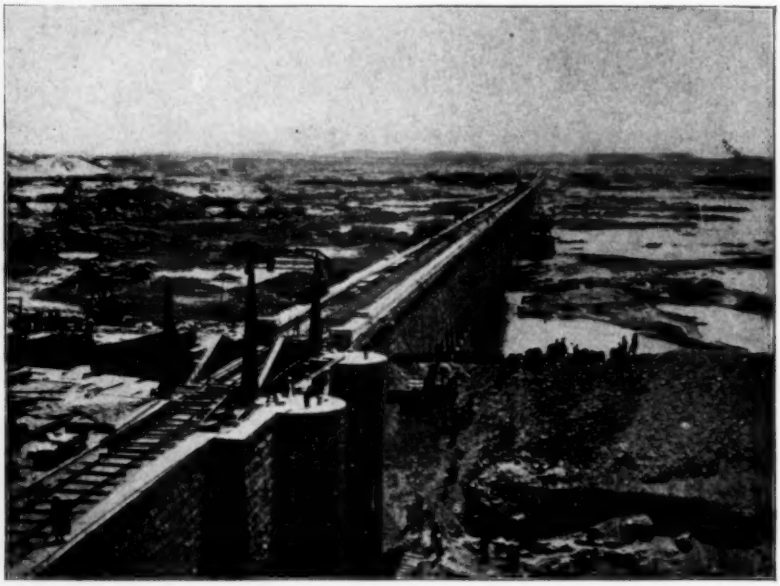


FIG. 4. SOUTH SIDE OF DAM, FROM WEST BANK.

weight were tipped into the cataract, and this was persevered with until finally a rubble mound appeared above the surface of the water. The first channel was successfully closed on May 17, 1899, the depth being about 30 feet and the velocity of current nearly fifteen miles an hour. In the case of another channel, the closing had to be helped by tipping railway wagons themselves, loaded with heavy stones, and bound together with wire ropes, making a mass of about 50 tons, to resist displacement by the torrent.

These rubble dams were well tested when the high Nile ran over them; and on work being resumed in November, after the fall of the river, water-tight sandbag dams or sudds were made around the site

of the Dam foundation in the still waters above the rubble dams, and pumps were fixed to lay dry the bed of the river. This was the most exciting time in the whole stage of the operations, for no one could predict whether it would be possible to dry the bed, or whether the water would not pour through the fissured rock in altogether overwhelming volumes. Twenty-four 12-inch centrifugal pumps were provided to deal if necessary with one small channel; but happily the sandbags and gravel and sand embankments staunched the fissures in the rock and interstices between the great boulders covering the bottom of this channel, and a couple of 12-inch pumps sufficed. The open rubble dam itself, strange to say, checked the flow sufficiently to cause a difference of nearly 10 feet in the level of the water above and below;

FIG. 5. FROM WEST BANK, LOOKING EAST, DURING ECLIPSE OF NOVEMBER 11, 1901.

but when the up-stream sandbag dam was constructed the difference was 20 feet, so that the down-stream sandbag dam was a very small one compared with the other.

The masonry of the dam is of local granite, set in British Portland cement mortar. The interior is of rubble, set by hand, with about 40 per cent. of the bulk in cement mortar, four sand to one of cement. All the face-work is of coursed rock-faced ashlar, except the sluice linings, which are finely dressed. This was steam-crane and Italian masons' work. There was a great pressure at times to get a section completed before the inevitable rise of the Nile, and as much as 3,600 tons of masonry were executed per day, chiefly at one point in the

dam. A triple line of railway, and numerous trucks and locomotives, were provided to convey the materials from quarries and stores to every part of the work. The maximum number of men employed was 11,000, of whom 1,000 were European masons and other skilled men (Figs. 3, 4 and 5).

Mr. Wilfred Stokes, chief engineer and managing director of Messrs. Ransomes and Rapier, was responsible for the detailed designing and manufacture of the sluices and lock-gates; 140 of the sluices are 23 feet high by 6 feet 6 inches wide, and 40 of them half that height; 130 of the sluices are on the 'Stoney' principle, with rollers, and the remainder move on sliding surfaces. The larger of the Stoney sluices weigh 14 tons, and are capable of being moved by hand under a head of water producing a pressure of 450 tons against the sluice.

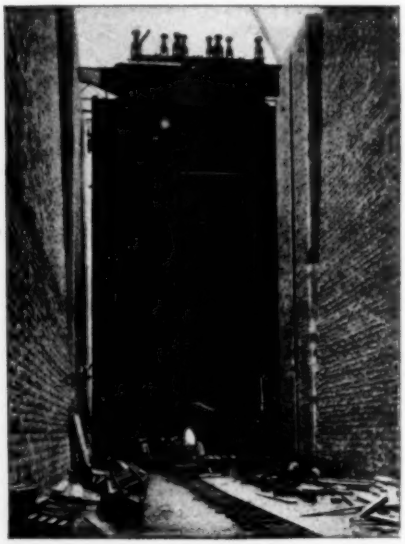


FIG. 6. NAVIGATION CANAL. FIRST LOCK-GATE FROM NORTH.

There are five lock-gates, 32 feet wide, and varying in height up to 60 feet. They are of an entirely different type to ordinary folding lock-gates, being hung from the top on rollers, and moving like a sliding coach-house door. This arrangement was adopted for safety, as 1,000 million tons of water are stored up above the lock-gates, and each of the two upper gates is made strong enough to hold up the water, assuming the four other gates were destroyed (Fig. 6).

When the river is rising, the sluices will all be open, and the red water will pass freely through, without depositing the fertilizing silt. After the flood, when the water has become clear, and the discharge of the Nile has fallen to about 2,000 tons per second, the gates without rollers will be closed, and then some of those with rolllers; so that between December and March the reservoir will be gradually filled. The reopening of the sluices will take place between May and July, according to the state of the Nile and the requirements of the crops.

Between December and May, when the reservoir is full, the island of Philæ will in places be slightly flooded. As the temples are founded partly on loose silt and sand, the saturation of the hitherto dry soil would cause settlement, and no doubt injury to the ruins. To obviate this risk, all the important parts, including the well-known Kiosk, or

'Pharaoh's bed,' have been either carried on steel girders or underpinned down to rock, or, failing that, to the present saturation level. It need hardly be said that, having regard to the shattered condition of the columns and entablatures, the friability of the stone, and the running sand foundation, the process of underpinning was an exceptionally difficult and anxious task. There were few men to whom I would have entrusted the task, but amongst those was Mat Talbot—one of the well-known Talbots who have done such splendid service as non-commissioned officers in the army of workmen employed by contractors during the past forty years; and well has he justified his reputation at home—where his last job was the most difficult part of the Central London Railway—and the commendation of Dr. Ball, who had charge of the works at Philæ.

It would be invidious to single out for special acknowledgment the services of members of a staff, where all have enthusiastically done their best for the accomplishment of the great work projected and patiently persisted in against all opposition, by Lord Cromer and his trusty lieutenant, Sir William Garstin, Under Secretary of State for Public Works. The successive Director-Generals of the Reservoirs were Mr. Willcocks, Mr. Wilson, and Mr. Webb; the chief engineers at Aswân, Mr. Fitzmaurice and Mr. May, and at Asyût, Mr. Stephens. The almost unprecedented labor and anxiety of arranging all the practical contractors' details of supply of labor, materials, and execution of the work fell upon the shoulders of Mr. Blue, except as regards Asyût, where Mr. McClure relieved him of a part of his responsibility.

As regards the initial stages of the project, I may say that when the Egyptian Government informed me that they wanted the works carried out for a lump sum, and no payment to be made to the contractor until the works were completed, I felt it would be idle to invite tenders until some arrangement had been made as to finance. As in other cases of doubt and difficulty, therefore, I went to my friend, Sir Ernest Cassel, and the difficulties vanished. The way was then clear for getting offers for the work. Sir John Aird and Co. were the successful competitors, and they have completed a largely increased quantity of work in less than the contract time, to the entire satisfaction of the Egyptian Government and of every one with whom they have been associated. The same recognition is due to Messrs. Ransomes and Rapier, and their able engineer and manager, Mr. Wilfred Stokes, who was unexpectedly called upon to complete all the complicated machinery of the sluices and gates in one year under the contract time, and did it.

SCIENTIFIC LITERATURE.

CHEMISTRY.

THREE Presidential addresses, delivered recently in this country and abroad, give admirable surveys of the present status, of past growth and of the future needs of chemistry. The address of Professor F. W. Clarke to the American Chemical Society, given December 30, 1901, on 'The Development of Chemistry' deals with the four principal agencies that have been instrumental in building the chemical structure of to-day; these are: private enterprise, the commercial demand, governmental requirements, and university teaching. At the beginning all these agencies had not been established, the two great stimuli to chemical research were the intellectual interest of the problem to be solved, and practical utility; these still have great influence, but the most important need at the present time, says Professor Clarke, is a well equipped and endowed research laboratory, in which to conduct systematic and thorough investigations.

Dr. Ira Remsen chose for his address to the same society, given a year later, 'The Life History of a Doctrine.' In a scholarly and witty way he sketched the early history, development and modern phases of the atomic theory, saying that in the light of late advances we must enlarge our conception of atoms. He pointed out that the many obituaries on the electrochemical theory of Berzelius were probably premature, since in the latest conception of atoms electrical charges play an important part. An atom charged with electricity is called an ion, and only then is it ready for action. At the same time President Remsen refers to physicists the explanation of some of the features of the theory of ions.

Professor James Dewar, in his address as president of the British Association for the Advancement of Science, delivered September 10, 1902, was of a more comprehensive nature, reviewing many aspects of science. Incidentally he compared the chemical equipments of England and Germany to the decided disadvantage of the former, stating that Germany possessed a professional staff one third larger in numbers and superior in quality. One firm in Germany, employing 5,000 workmen, has a staff of 160 chemists, 260 mechanics and engineers, besides 680 clerks. Owing to the high education and practical character of their chemists German manufacturers enjoy a monopoly. Passing from this theme, Professor Dewar gave some of the interesting results obtained in his researches on low temperatures, especially in liquefying hydrogen and helium. The whole address, which is very readable, can be found in the October numbers of *Science*. Besides these addresses another one by Dewar must not be overlooked, the 'Centenary Commemoration Lecture' at the Royal Institution.

The Bi-Centennial of Yale University, celebrated in 1901, was appropriately marked by the publication of several superb volumes containing chemical research conducted by professors and instructors in that institution. Two of these are from the Kent Chemical Laboratory, and embody the labors of Professor F. A. Gooch, and of some of his assistants; the other two are from the Sheffield Scientific School, and contain chiefly the labors of Professor Horace L. Wells. The

papers are limited to the ten years preceding their publication and reflect great credit on their authors. To attempt any synopsis of the contents of these volumes would lead to technical details beyond the scope of these columns.

Text-books in English and in other languages continue to flow from the press in undiminished numbers; some are very elementary, giving no novelty in treatment nor other advantages over the host of those preceding them, but others are on a higher plane, endeavoring to embody the most recent theories and to adapt them for the purposes of instruction. One of the most praiseworthy of the latter group first appeared in Holland in 1898, was soon translated into German, and two years later into English. Its author is Dr. A. F. Holleman, professor at the University of Groningen, its translator is Dr. Harmon C. Cooper, of Syracuse University, and it bears the imprint of John Wiley and Sons, New York City. Holleman's text-book combines the new achievements of physical chemistry with the mass of long-established facts of inorganic chemistry so as to form a unified whole; it makes it unnecessary for beginners to get acquainted with the common phenomena of elementary chemistry by the study of one book written on the old plan, and then to take up the independent study of those laws of physical chemistry established by Ostwald, van't Hoff, Arrhenius, and their disciples, as set forth in some other manual devoted to those subjects. All these features are combined by Holleman in a single graded course, making it a superior, up-to-date work. The translation by Dr. Cooper is satisfactory and free from ambiguity.

Another book of very high grade is that by Dr. Mellor, of Manchester, England, entitled: 'Higher Mathematics for Students of Chemistry and Physics.' Chemistry is developing along mathematical lines, and it is evident that its students must hereafter be practical mathematicians. Of several books applying mathematics to the scientific evolution of chemistry, Mellor's book is very complete and satisfactory, and can be warmly recommended.

THE PROGRESS OF SCIENCE.

THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH.

SCIENTIFIC medicine in the United States is to be congratulated on the establishment of a laboratory for research that may be compared with those of the great European capitals. There are in this country more than a hundred thousand practising physicians, somewhat over two hundred medical journals and a large number of medical schools, and many important advances in technical medicine are due to American practise. Opportunity for systematic research has, however, been hitherto lacking. This will be supplied by the laboratory to be built in New York City on the foundation of Mr. John D. Rockefeller. It will be remembered that two years ago Mr. Rockefeller gave $200,000 for the establishment of an institute for medical research and placed the endowment in the hands of a strong and compact board of directors, consisting of Dr. William H. Welch, Baltimore; Dr. T. Mitchell Prudden, New York; Dr. Theobald Smith, Boston; Dr. Simon Flexner, Philadelphia; Dr. Hermann M. Biggs, New York; Dr. C. A. Herter, New York; Dr. L. Emmett Holt, New York.

The fund could be used for current expenses, and with it grants have been made, varying in amount from $200 to $1,500, to over twenty investigators who have carried forward their work at American and foreign universities. The directors, however, believed that, in addition to such individual studies, there was needed a central institution for certain lines of research with an adequate equipment and permanent endowment. Towards this purpose Mr. Rockefeller has given $1,000,000, which will be used for the purchase of land, the erection of buildings and the organization of the work, and it is understood that Mr. Rockefeller is prepared to give an additional endowment when needed. A site has been secured in New York City overlooking the East river, and it is hoped that the laboratory will be completed and ready for the commencement of work in the autumn of 1904. The buildings will include a small hospital which will be maintained in close association with the experimental work. The institute has assumed the publication of *The Journal of Experimental Medicine*, which will remain under the editorial supervision of Dr. W. H. Welch, professor of pathology in the Johns Hopkins University and president of the board of directors of the institute. The directors will also undertake the diffusion of knowledge by the means of lectures, publications and hygienic museums that will tend to the prevention and cure of disease. Dr. Simon Flexner, professor of pathology in the University of Pennsylvania, has been appointed scientific director of the laboratories, and there will be associated with him the heads of the different departments that will be established.

THE SMITHSONIAN INSTITUTION.

THE board of regents of the Smithsonian Institution held an adjourned meeting on March 12, at which matters of much importance for the institution and for the progress of science in America were discussed. It was decided that in addition to the annual meeting in January for the transaction of routine business, there shall hereafter be held two additional meetings, one in December and one in March,

when the affairs of the institution may be discussed fully and freely. A committee that had been appointed to consider the powers and duties of the executive committee did not make a final report, but it was the general opinion that this committee should have regular and stated meetings. Dr. A. Graham Bell introduced a series of resolutions and moved that they be referred to the committee appointed to consider the powers of the executive committee. They will be reported on and fully discussed at the meeting in December. The resolutions are as follows:

The secretary shall nominate, and by and with the advice and consent of the board of regents, shall appoint the heads of the various bureaus supported by congress under the direction of the Smithsonian Institution—*to wit*—the National Museum, the Bureau of American Ethnology, The National Zoological Park, the Bureau of International Exchanges, and the Astrophysical Observatory.

The secretary shall have power to fill up all vacancies that may happen in these offices during the intervals between meetings of the board, by granting commissions which shall expire at the next meeting of the board of regents.

The head of each bureau shall nominate, and, by and with the advice and consent of the secretary, shall appoint the subordinates in the bureau under his charge.

The heads of the bureaus shall be termed directors; and the board of regents hereby creates the offices of director of the National Museum, director of the Bureau of American Ethnology, director of the National Zoological Park, director of the Bureau of International Exchanges, and director of the Astrophysical Observatory, and instructs the secretary to fill these offices by temporary appointment to expire at the next meeting of the board, when nominations shall be presented for confirmation by the board.

It will thus be seen that the entire question of the organization of the Smithsonian Institution and its relations to the government bureaus is under consideration by the regents. At the meeting two other matters of general interest were discussed. Congress has made an appropriation of three and a half million dollars for a new building for the U. S. National Museum, the construction of which has been placed in the hands of Mr. Bernard R. Green. The secretary, with the advice and consent of the chancellor and the chairman of the executive committee was designated to cooperate with Mr. Green.

Owing to the need of moving the body of James Smithson from the grave in which it rests at Genoa, it was proposed last year by Dr. Bell that the remains be brought to this country, where congress would doubtless erect over them a suitable monument in the grounds of the Smithsonian Institution. This suggestion was not adopted at the time, but Dr. Bell has now offered to have the remains removed at his expense, which offer the regents will doubtless be glad to accept.

THE DEPARTMENT OF AGRICULTURE.

THE appropriation for the United States Department of Agriculture provided by the recent session of congress covers a total of practically six million dollars, an increase over that for the current year of $769,140, including an emergency appropriation of a half a million dollars. The increased funds are for the most part to enable an extension of the work of the department along its present lines, rather than to take up new special features. The largest increases are for the Bureaus of Animal Industry, Plant Industry, Forestry and Soils.

The Bureau of Animal Industry receives $1,287,380, an increase of $100,000 for the extension of its meat and other inspection work, and an emergency appropriation of $500,000 is placed at the disposal of the secretary of agriculture to stamp out the foot-and-mouth disease, which has recently raged in several of the New England states, and other contagious diseases of animals which may appear.

The total appropriation for the Bureau of Plant Industry is $674,930, an increase of $62,200 for its work in vegetable pathology and physiology, botanical investigations, studies of the pomaceous fruits and their preservation, and experiments with grasses and forage plants. These increases will enable carrying on the plant breeding work on a somewhat larger scale to secure crops resistant to alkali, disease-resistant beets, and the improvement of Indian corn. More extensive investigations and field trials will be made of the nitrogen-fixing organisms in growing leguminous plants; and among the plant diseases the Texas root-rot of cotton and the California vine disease will receive special attention. The increase for botanical investigations will be used for developing the studies of poisonous plants, particularly on the western ranges. The fund for the purchase of seeds for congressional distribution is increased by $20,000, being now $290,000, but an additional $10,000 is allowed to be expended out of this fund for the introduction of seeds and plants from foreign countries, making the fund for that purpose $30,000.

The amount for the Bureau of Forestry is increased to $350,000, which is $58,140 more than the current appropriation, and will enable an extension of its forestry and timber investigations and the preparation of working plans for owners of woodlands.

The Bureau of Soils receives $212,480, $42,800 more than the present year. The increase will be used in expanding the soil survey and the tobacco work, which is in charge of this bureau. Surveys will be made the coming year in thirty-two states, which shows the wide distribution of this work. The tobacco investigations will be confined principally to experiments with the Cuban filler tobacco in Alabama, middle South Carolina, and eastern Texas, where soils have been located similar to those on which it is successfully grown.

The scientific staff of the Weather Bureau is increased somewhat, an assistant chief being added, and the bureau is authorized to erect five new observatories and to establish cable communication between Block Island and Narragansett Pier, with terminal buildings and equipment at each place. Its total appropriation amounts to $1,248,520.

The appropriations for the experiment stations in Hawaii and Porto Rico are increased to $15,000, making them uniform with the stations in other states and territories, and $5,000 is appropriated for taking up the farmers' institute work with a view to assisting the organizations in the different states and territories and making them more effective means for the dissemination of the results obtained at the department and at the agricultural experiment stations. These increases bring the total amount for the agricultural experiment stations and the Office of Experiment Stations (including irrigation investigations and investigation in human nutrition) up to $895,000.

The Division of Statistics is raised to the grade of a bureau and given an increased appropriation of $15,500 for general maintenance, making a total of $156,660.

Other items carried by the act are $85,300 for the Bureau of Chemistry, an increase of $11,600; $77,450 for the Division of Entomology, an increase of $10,000; $51,850 for the Division of Biological Survey, an increase of $6,000; $229,320 for the Division of Publications, $105,000 of which is to be used for the preparation and printing of Farmers' Bulletins; $16,000 for the Division of Foreign Markets; $35,000 for Public Road Inquiries, an increase of $5,000; $20,000 for the Library; and $138,210 for administrative, contingent and general expenses.

The growth of the department is indicated in a general way by the amounts authorized for the rent of office and laboratory buildings. Starting some twelve years ago with an item of $900, the amount authorized for rent of buildings has steadily increased year by year until in the present bill it amounts to $27,500. This shows conclusively the inadequacy of the present buildings, which led the last session of congress to appropriate $1,500,000 for a new agricultural building, plans for which are now in course of preparation.

The agricultural appropriation act does not carry the appropriation for printing the publications of the department, except in the case of the popular series known as 'Farmers' Bulletins.' The department's allotment out of the general printing fund is $185,000, an increase of $10,000, and $300,000 is provided for printing and binding a half million copies of the 'Year-book.' Adding to this the cost of the regular and special reports, which are printed by order of congress, brings the amount for printing the department publications up to approximately three quarters of a million dollars. In the last fiscal year 757 separate publications were issued in an aggregate edition of over ten million copies, some six million of which were 'Farmers' Bulletins.' This is a larger number of separate publications and of total copies than are issued by any other department of the government, and stamps the Department of Agriculture as the greatest agency in the world for the dissemination of popular and technical information on agriculture and agricultural science.

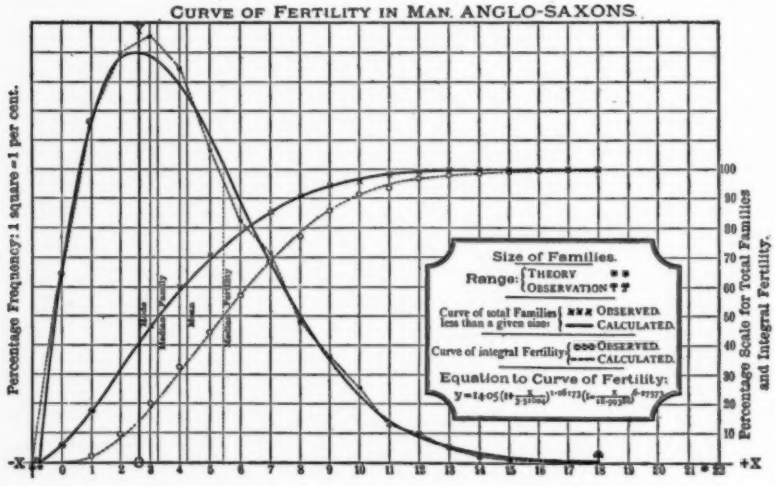
THE QUESTION OF THE BIRTH RATE.

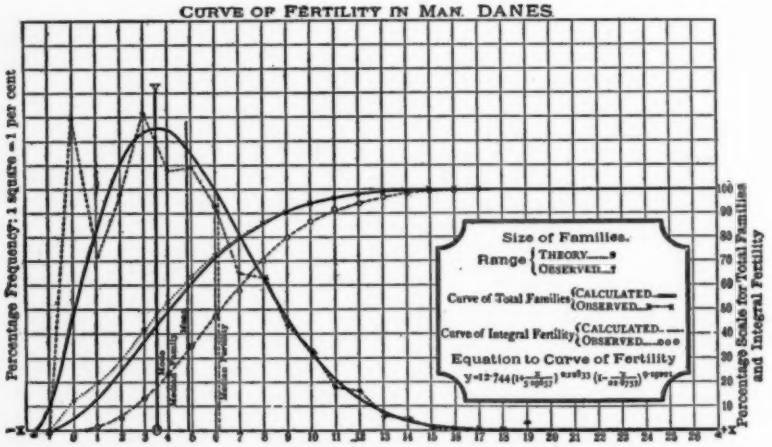
JUST one hundred years ago, in 1803, was published the edition of Malthus's 'Essay on Population' which has had a considerable influence on economic theory and aided Darwin in thinking out his principle of the origin of species by natural selection. Malthusianism has become a current word with somewhat sinister implications, quite foreign to the spirit of the kindly clergyman, who announced the theory that population tends to increase more rapidly than the means of subsistence. If this were true population must be limited by moral restraint, vice or misery, and Malthus urged people not to marry until they had a fair prospect of supporting a family. Owing to the applications of science during the past century the means of subsistence in civilized nations have increased far more rapidly than the population. Malthus's proposition has become inverted; the production of goods increases in geometrical ratio, whereas the production of people occurs with an ever decreasing increment. It is no longer an economic question of starvation, but a sociological question of race suicide.

The subject has during the past month become prominent in newspaper discussions owing to statements made by the president of the United States and by the president of Harvard University. President Eliot has shown that graduates of Harvard do not reproduce themselves. Statistics from the colleges for women have also been compiled which prove that the graduates are not self-perpetuating. From the point of view of social evolution there would be certain advantages in the need of recruiting the ruling classes from a larger group, as this would give room for natural selection. As a matter of fact President Eliot's conclusions are contradicted by the only large study of the subject at hand, that by Rubin and Westergaard of Copenhagen marriages. It appears from some thousands of cases that while the birth rate is slightly smaller for the professional and upper classes than for artisans, the average number of surviving

children is greater for the former, being about 3.31 as compared with 3.14. It may be that Harvard graduates have as large surviving families as those of the same race, but of lower social class.

It is unfortunate that statistics are not at hand on the marriage rate and birth rate in relation to the conditions on which they depend. The questions involved are of the utmost practical importance and should be taken up at once by the national and state governments. The birth rate in France where the population is stationary, is about 22 per thousand. In Great Britain it is 29, in Germany 35 and in Russia 52. In Massachusetts the birth rate was last year 25.07 and the marriage rate 8.67. Even if all illegitimate children are attributed to the married, the average size of family would be less than three. The foreign born have a much larger fertility than the natives, and it is quite possible that the New England stock has a mean family of only two, as President Eliot finds to be the case with Harvard graduates. President Eliot appears to be mistaken in attributing the small families of Harvard graduates in part to postponement of marriage due to protracted educa-


CURVE OF FERTILITY IN MAN. ANGLO-SAXONS.
Percentage Frequency: 1 square = 1 per cent.
Percentage Scale for Total Families and Integral Fertility.
Size of Families.
Range: THEORY ** OBSERVATION ††
Curve of total Families less than a given size: *** OBSERVED. —— CALCULATED.
Curve of integral Fertility: ooo OBSERVED. ----- CALCULATED.
Equation to Curve of Fertility:
-X
+X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Percentage Frequency: 1 square = 1 per cent
Percentage Scale for Total Families and Integral Fertility
Size of Families.
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Curve of Total Families CALCULATED.—— OBSERVED...*—*
Curve of Integral Fertility CALCULATED.---- OBSERVED.....ooo
Equation to Curve of Fertility
-X
+X

tion. The age of marriage of men of the upper classes in Copenhagen, with mean families of 4.5 was over 32, whereas it appears that the professional classes in the United States marry at an earlier age than this.

It is surely a serious problem when the more civilized races tend not to reproduce themselves. It is difficult of explanation by the laws of heredity and natural selection. We may assume that in the lower animals the number of offspring is most favorable for the survival of the race. In man there may be a selective death rate tending to reduce large families, but it does not appear to be an important factor. One quarter of the married population produces one half of the next generation, and if fertility is inheritable or correlated with inheritable traits the size of families should increase rapidly. If there were a complete correlation between fertility in mother and daughter, the size of families would be doubled in the fifth generation. It appears that physiological fertility is held in check by prudential restraint, but it is not clear why the psychological factors are not subject to natural selection and social tradition. Those who would have large families should supplant those who would not.

We reproduce from Professor Pearson's 'Chances of Death' two diagrams. The first is based largely on 2,279 marriages of a Connecticut quaker family, to which a skew frequency curve is fitted. The modal family, or most frequent family, falls between two and three; the median family, or the family of such size that there are as many larger as smaller, is 3.29; the mean or average family is 4.22, and the range or maximum family is 22.5. The second curve, for 1842 families of the professional and upper classes in Denmark, shows a somewhat higher fertility. Both curves indicate an artificial limitation in the deficiency, as compared with the theoretical curve, of families of five and six; and this would probably be much more marked in French or in recent Anglo-Saxon families. There is indeed urgent need of further investigation into the facts of the birth rate. Applied science may have at the end of the present century problems more pressing than the increase of the means of subsistence; there must be people to subsist.

THE RHODES SCHOLARSHIPS.

THE scholars to be appointed under the terms of the will of the late Cecil Rhodes will go into residence at Oxford next year, and the best methods for selecting them are now being considered. The Prussian ministry of education has addressed a letter to the Oxford colleges asking information as to the reception of the fifteen scholars to be nominated by the German emperor. It is assumed that students will go to Oxford direct from the gymnasium, and it is asked whether the *Abiturienten-Zeugnis* which admits to the German universities will be accepted. Among other things information is wanted as to whether students may pursue studies preparatory to the professions and whether scholars may be appointed for a shorter period than three years.

Dr. Parkin, of the Toronto Grammar School, who was himself a colonial student at Oxford, has been commissioned to secure information for the use of the executors in framing a workable plan for American and colonial students. He has visited Oxford to learn the sentiments of the educational authorities and finds that most of the colleges will be glad to welcome the scholars. He is now in America holding conferences with educators and others, and will proceed to the different British colonies. The chief practical questions seem to concern the methods by which the scholars shall be appointed and the stage in their education at which they shall go to Oxford. The appointing authority is complicated in this country owing to

the existence of state and private institutions with no machinery for correlation, and some question has already arisen in one or two of the western states as to the part to be taken by the board of education, the state university and the private institutions. In several conferences that have been held in the East the question has arisen as to whether the boy should go to Oxford to begin his college work or after he has taken his A.B. degree here.

We see no reason why the intentions of Mr. Rhodes should not be followed. These were certainly that the scholars should spend the three years in residence at one of the Oxford colleges preparing for the B.A. degree, and that they should be selected by the schools, not by the universities. Mr. Rhodes proposed that the qualifications should be rated on a scale of ten, one point for leadership in manly outdoor sports and three for qualities of manhood, these to be determined by fellow students, then two points for force of character to be assigned by teachers, and lastly four points for scholarship to be determined by examination. Mr. Rhodes does not seem to have considered the difficulty of comparing the claims of students from different schools, but if a candidate is nominated by each school wishing to do so, the central state authority could give the competitive examination and select the scholar as the result of this and of his school record. It seems proper that Mr. Rhodes's intention should at least be given a trial, even though the presidents of American universities think it better that B.A.'s should be sent to Oxford for research work. There is indeed much to be said for Mr. Rhodes's plan of selecting the scholars and for his intention that they be undergraduates. Oxford is not a particularly good place for graduate work, but its college life has certain admirable aspects not to be found in American or continental institutions. It would not do to educate all American boys by the Oxford method, but much gain will accrue to the educational, political and social life of the country by sending thirty each year thither.

There appears to be some opposition to the Rhodes scholarships. The students of Göttingen are said to have voted not to accept them, and some American newspapers print editorial criticisms not always well informed. The New York *Sun*, for example, says 'The Rhodes bequest was based upon a flagrant misconception of facts, and inspired by an ill-considered purpose.' This opposition seems to be based on the assumption that Harvard and Berlin are better universities than Oxford, and that the student will be anglicized to the advantage of Great Britain. Harvard and Berlin are of course better universities than Oxford, but the Oxford College is *sui generis*, and its influence on the students is great and on the whole beneficial. It would doubtless be an excellent economic investment for Great Britain to send one hundred students to study at Berlin and Harvard, and it certainly seems to be an advantage for the United States to send one hundred students to Oxford to be educated at the cost of Great Britain.

CENSORSHIP OF THE PRESS IN RUSSIA.

THE issue of THE POPULAR SCIENCE MONTHLY for October, which contained an article by Dr. F. A. Woods reviewing heredity in the Romanofs prior to 1762, was censured by the Russian government in a curious manner. The leaves containing the article were cut out from the number and the title on the table of contents was so inked that it could not be read. This seems to show a considerable degree of conscientiousness on the part of the censor, as it would have been easier and less exciting to the curiosity of subscribers to have simply destroyed the numbers. The incident recalls, however, the in-

tolerable state of affairs to which the Russian press and people must submit. Russian newspapers are of two classes, censored and uncensored. The former must show everything that is printed to a local censor beforehand, the latter are subject to the minister of the interior, who suppresses or punishes them as he sees fit. It is said that the conditions are not quite so bad as they were, but a 'confidential' letter of instructions sent to the uncensored papers from the ministry of the interior on the twenty-second of last July gives striking information as to the limitation imposed on freedom of speech. Among the large number of subjects regarding which it is forbidden to publish news or criticism we quote the following coming within the scope of this journal:

Information and articles concerning disorders in the higher educational establishments, whether secular or clerical, and disciplinary punishments inflicted on those taking part in such disorders, . . . and, in general, all news relating to the internal life of these institutions, except when the competent educational authority has consented to such publication.

Information concerning disorders, in our factories and industrial works, or any other breaches of public order and tranquility, except when permission for publication has been given by the higher police authorities.

Information concerning the appearance of epidemic diseases among the population, or the spread of the plague in Russia and the adjacent countries, except when permission for publication has been given by the medical department of the Ministry of the Interior.

Historical and critical disquisitions, articles and documents, printed in specialist or strictly scientific journals or other works, in cases where such articles, etc., serve an exclusively scientific purpose, and where, by reason of their contents, their distribution among a wide circle of readers might lead to undesirable results.

We shall look forward with interest to learn whether the censor discovers this note and cuts it out of the copies of the MONTHLY going to subscribers in Russia.

MILEY'S COLOR PHOTOGRAPHY.

PROFESSOR W. G. BROWN, of the University of Missouri, brought to the attention of the Chemical Section of the American Association for the Advancement of Science, at the recent Washington meeting, a new method of color photography of considerable interest, due to M. and H. M. Miley, of Lexington, Va. Two photographs were shown—a copy of Rembrandt Peale's Washington in the uniform of a colonial officer, and a plate of peaches. The process is a three-color film one, in which the essential modification of existing processes is the use of pigmented gelatine films in place of stained ones.

In making photographs by this method, three negatives are taken in colored light, the light being obtained by passing ordinary light through a medium of proper color interposed between the lens and the plate, usually a screen of colored glass or some coloring matter placed between sheets of thin glass. One negative is taken through a red screen, a second through a green screen and a third through a violet screen. The colors, red, green and violet, used for the screens should be such as transmit rays falling within a limited portion of the spectrum. The photographic plates used for the negatives must be adapted to the color of the light to which they are exposed; for the negative exposed to the red light an orthochromatic plate stained with cyanin solution, for that to the green light an unmodified orthochromatic plate and for violet light an ordinary gelatin-silver-bromid plate is used. From the negatives obtained positives are made of carbon tissue (bichromated gelatin pigment paper). The carbon tissue, perhaps better, pigment tissue, used with the red light negative is charged with an inalterable blue pigment, the blue being the complementary of the red used in the production of the negative. The

pigment tissue for the red and yellow positives, that is, the tissue used with the green and violet-light negatives is charged with the complementary inalterable red and yellow pigments. The pigment tissue, of whatever color, is sensitized, exposed and developed in the usual way with some modifications made to facilitate the manipulation during the development, transference and subsequent superposition of the films.

The yellow positive is made first and transferred to gelatine-coated paper which forms the final support of the photograph, the red positive is next made and before drying is superposed on the yellow positive, finally the blue positive is superposed on the other two. The resulting photograph, if the negatives have been of the right density, the pigments of the proper colors and the technique right, is one of which it can be safely said that none made by any other process can be compared with it. The photographs are superior to three-color prints, just as a carbon photograph is superior to a half-tone print, and are superior to an ordinary photograph in the same measure that a carbon print is. Miley's color photographs possess all the richness, depth and permanence of carbon photographs with the addition of color. Unlike the three-color half-tone prints, there is no break in the continuity of the color. The texture and minute details of the subject are faithfully reproduced with a naturalness that can only be compared with the originals.

So far the process has been used for still life, landscapes and paintings, but it is possible to take portraits by it, as the time of exposure through the red screen is about fifteen seconds and, with a suitable plate-holder and screen-holder, all three plates could be exposed easily in less than thirty seconds. It is hardly necessary to say that the method can be used for the production of transparencies and lantern slides. These, however, have not yet been made.

SCIENTIFIC ITEMS.

WE regret to record the deaths of Professor William Harkness, the eminent astronomer, past president of the American Association for the Advancement of Science; of Dr. Norman Macleod Ferrers, F.R.S., the mathematician, master of Gonville and Caius College, Cambridge, and of Mr. James Glaisher, F.R.S., known for his work in meteorology and aeronautics.

MR. JOSEPH LARMOR, fellow of St. John's College, Cambridge, has been elected Lucasian professor of mathematics in succession to the late Sir George Gabriel Stokes.—Professor E. F. Nichols, of Dartmouth College, has been elected to a chair of physics in Columbia University.—Mr. Stewart Culin, recently curator of the Museum of Science and Art of the University of Pennsylvania, has become curator of ethnology to the Museum of the Brooklyn Institute of Arts and Sciences.—The Lucy Wharton Drexel medal of the University of Pennsylvania was presented to Professor F. W. Putnam at the Founder's Day celebration on February 21.—Dr. Albert B. Prescott, professor of chemistry in the University of Michigan, has been given the degree of LL.D. by Northwestern University.

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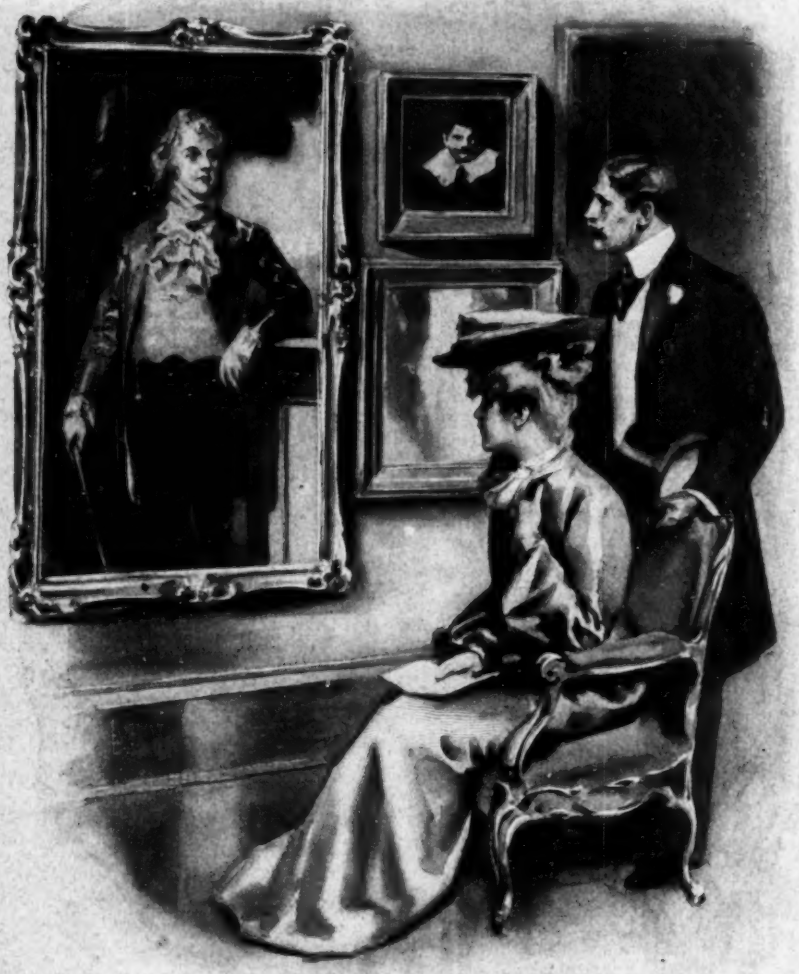

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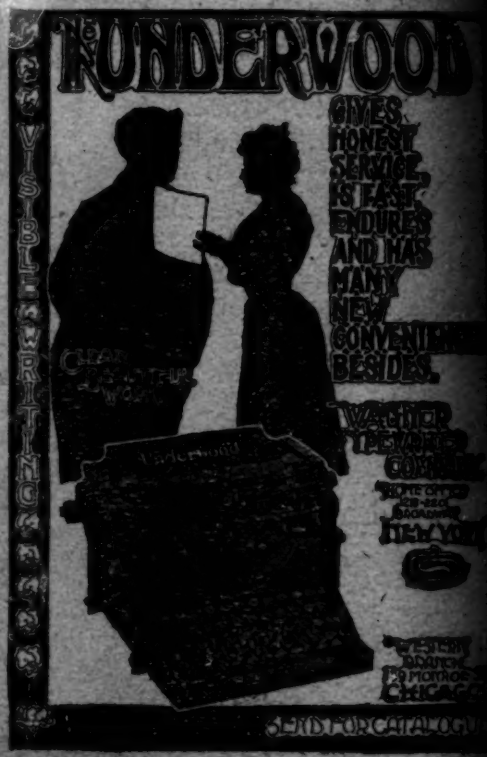
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